SCIENCE ABSTRACTS.

Section A.—PHYSICS.

SEPTEMBER 1914.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

SEPTEMBER 1914.

GENERAL PHYSICS.

1470. *Improved Form of Integrator.* **J. G. Johnstone.** (Inst. Engin. and Shipbuilders, Trans. 67. pp. 14–27 ; Discussion, pp. 28–36, April, 1914.)—The instrument here considered is of the kind in which a pointer is moved over the boundary of an area to be measured or integrated, and in which the "area" and "moment" are recorded by means of small wheels which roll and slide over the surface containing the given area. Full details are given of the instrument and method of use. A simple theory is also given. Applications are made to (i) the integration of the body plan of a vessel's form in order to obtain the displacement curve ; (ii) integrating a body plan of a vessel's form in order to obtain the displacements and moments for cross curves of stability. In the *discussion*, **Scribanti** gave a more complete theory of the instrument, showing that the use of the instrument would give only approximate results. The correction terms are discussed, and it appears that in spite of the neglect of these in the original paper, the instrument constitutes an advance on other integrators, one point rendering it particularly valuable for some purposes being that it is unnecessary with this instrument to trace completely round an area. A. W.

1471. *Optical Torsion Dynamometer.* **V. Vieweg.** (Zeitschr. Vereines Deutsch. Ing. 58. pp. 1016–1018, June 20, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—Diagrams and description are first given of a torsion dynamometer due to Amsler, in which a stroboscopic method of determining torsion is employed. In the second instrument dealt with, a lens system, with its axis parallel to the shaft, is carried by a disc (C) concentric with the shaft and carried by a tube connected at its farther end to the shaft. This disc (A) is situated at a distance from the end of the tube equal to the focal length of the lens system, and this end of the tube carries a second disc (B) with a scale which can be viewed through the lens. A second scale is carried by another disc (C), nearly touching disc (B), and secured to the end of a tube similar in all respects to the first, and attached at its other end to the shaft. A source of light illuminates the scales, and the difference of the readings when stationary and when under torsion is a measure of the torsion on the length of shaft between the points where the tubes are attached. [See also Abstracts Nos. 1042 (1913), 641 (1914).] A. W.

1472. *Modifications of a Balance for Ease and Quickness of Weighing.* **G. A. Shakespear.** (Phil. Mag. 27. pp. 990–994, June, 1914.)—In the use of a good physical balance the accuracy of weighing is mainly limited by (*a*) the accuracy of the weights, (*b*) constancy of temperature in the balance case, (*c*) the accuracy with which the position of the rider can be read, and (*d*) the magnitude of the smallest measurable deflection of the beam. Frequently details (*a*) and (*b*) are not sufficiently regarded. Theoretically, the sensitiveness may be increased so that the smallest appreciable change of position of the rider produces an observable deflection of the beam. In practice, however, it is found advisable to have a degree of sensitiveness for which a comparatively large change of position of the centigramme rider produces no appreciable change in deflection. In other words, the rider is usually too small and the means of measuring deflection not sufficiently delicate. In the balance described the rider is therefore comparatively large (either 0·5 or 0·05 gm.), and the deflection is observed optically by using a concave mirror attached to the beam. The rider beam runs from end to end of the beam, the upper edge being in the plane of the knife-edges. It is divided into ten equal divisions, each of which is subdivided into ten smaller divisions. The rider is in the form of an elongated ring which surrounds the rider beam, and is provided with a hook at its upper part. The rider is moved by means of a thin silk cord passing through a slit at each end of the balance case. The lower part of each slit slopes downwards and forwards, the upper part being vertical and in the same plane as the rider beam, but rising above the level of the top of the rider. Small weights at each end of the cord keep it clear of the beam when not required to move the rider. The effect of using the concave mirror is to provide a pointer of considerable length but with small mass and moment of inertia, so that the period of oscillation is appreciably reduced. There is, moreover, no parallax. In weighing, the weights are placed in the right-hand pan, the rider being at its zero mark at the left-hand end of the beam. Weights to the nearest gramme (less than the weight of the body) are put into the pan if the ½-gm. rider is used; the case is closed, and the fractions of a gramme are given by one setting of the rider. A balance fitted in the manner described has been found to give great saving of time and labour in weighing. A. W.

1473. *An Instrument to Measure Wind-pressure.* **Giessen.** (Zeitschr. Vereines Deutsch. Ing. 58. pp. 836–840, May 23, 1914.)—By using the instrument described it is possible to obtain a continuous record of the resultant wind-pressure exerted upon any object, including the suction effect on the lee side, and also the line of action of the pressure. The instrument consists essentially of an upright bar on the top of which the object to be investigated is mounted. The bar is supported in a way fully described in the original paper, whereby the forces required to keep it in the vertical when the object fixed to the bar is exposed to the wind can be accurately and automatically recorded. The magnitude and line of action of the resultant pressures are not recorded directly—they have to be computed from a number of force curves treated collectively. R. C.

1474. *Report of the National Physical Laboratory for* 1913. (Engineering 97. pp. 881–882, June 26; 98. pp. 27–31, July 3, and pp. 74–77, July 17, 1914.)—A radium testing department has been opened and the establishment of a radio-telegraphic research laboratory is under consideration. Wind-pressure investigations with stiffer diaphragms on the high-level girders of the lower bridge show that wind pressure on a structure in a uniform current can be predicted by taking the mean of a sufficient number of observations in the open air. Appliances for testing the efficiency of power transmission through gear boxes have been designed and built for the War Office Mechanical Transport Committee. The speed range is from 37 to 1000 r.p.m.; influence of temperature and extent of oil-filling are under investigation. Important investigations are in progress concerning fluid friction in pipes (water, air, and oil); results obtained to date are set forth in the Report. The impact testing machine used for impact tests on screw threads and couplings has been modified to suit the greater tensile strength of railway-carriage couplings now used. Researches now proposed concern the methods of notched bar testing and the resistance of materials to combined stress. Tests of resistance of keys and keyways to stress reversal (± 20,000 in.-lbs. torque on a 2½-in. shaft) indicate that a key should be an absolute fit on the sides with evidence of fit on top and bottom; each side should have a draught of 1 in 2000; shaft and hub ground to a hand-push fit and failure assumed when relative measurement of shaft and hub = 0·01 in. with ⅝ × $\frac{7}{16}$ in. and ⅝-in. square keys: the shaft tested broke under ± 8 tons per sq. in. before half the named displacement was reached. In the aeronautics department much work has been done on the longitudinal and lateral stabilities of Bleriot models, and many aerofoils have been tested for the Royal Air-Craft Factory and private firms. The whirling table is being used to investigate pressure distribution round a propeller blade. Since Jan., 1913, 72 different kinds of stone have been tested for attrition, impact, abrasion, and cementation in the Road Board Laboratory. Various improvements have been made in the circular track and road machine; useful information has been obtained. Jakeman's machine for tracing longitudinal and cross profiles show that no waves form in a smooth uniform road if the testing machine be started very slowly. Traffic vibrations in St. Paul's and the Clock Tower were examined by two seismographs, an apparatus of the boom type measuring horizontal components and a bar instrument measuring vertical components. Kinematograph records were taken with both instruments. Oscillations of the order of 0·0001 in. were caused by 3 motor buses at 12 miles per hour. In the Clock Tower, horizontal movements were more marked. Some 30 different brake-lining materials have been tested to determine coefficients of friction under different loads, speeds, and temperatures. Tests made at rubbing speeds 600 ft., 2900 ft., and 5900 ft./min. and pressures 5 to 180 lbs. dry and up to 290 lbs./sq. in. lubricated showed for cotton-fibre, woven asbestos, teak, leather, and vulcanized fibre:—Coefficients of friction (on cast iron) 0·55–0·65; 0·3–0·35; 0·25; 0·2–0·3; 0·5. Increase with speed—nil throughout. Variation with increase of pressure—increase, nil, nil, decrease, unknown respectively. Variation with increase of temperature—increase, increase, nil, great decrease, increase but burns soon. Cotton fibre and woven asbestos gave best and most uniform results; their extensive use is justified. In the Froude tank 75 models were tested for shipbuilders; in one instance 25 % power saving was effected by acting on suggestions made by the Tank Department; the lines of many vessels have been determined in connection with the tank tests. Important improvements have been made in the apparatus for testing hydroplane floats. Numerous additions have been made to the equipment of the metallurgical departments. Tests on light aluminium alloys on test-pieces of various forms, pure and intentionally impure, are being continued on an extensive scale. An experimental rolling mill has been installed to deal with hard and soft alloys of Al, Cu, Zn, etc. An improved cascade furnace has been built for high-temperature work and kathode-ray bombardment is to be tried in silica tubes for melting-point determinations. Balloon fabrics are best protected by metallisation, say by the Schoop process. The value found for the international ohm is referred to [see Abstract No. 955 (1914)]. The London and South-Western Railway Company undertake that their electrification scheme shall not increase magnetic disturbances at the Laboratory more than 20 %. Important preliminary conclusions have been reached concerning equilibrium in the Weston cell. Tests on condenser dielectric losses cover the range of frequencies used in radiotelegraphy; castor oil has 1·088 power factor at 10^6 ∿ and should not then be used. Over 850 wave-meter coils have been calibrated; some up to 6000 m. wave-length. The Duddell arc and tuning-forks have been used to calibrate commercial frequency meters from 800 to 800 periods. Self-inductance is of prime importance in high-frequency shunts; at certain frequencies, a solid is preferable to a stranded conductor. A means has been found to mitigate head-lamp dazzle; useful results are promised *re* constants of diffusing surfaces and media; a successful spinning apparatus is in use for high c.p. lamps. A small silicon-iron transformer proves trustworthy at a frequency of 2×10^6 ∿. Testing a.c. meters for official tests, etc., is an important and growing part of the work done. Three-phase wattmeters with transformer complete can now be tested under practical conditions. The pernicious effect of light on ebonite has been studied for the Admiralty. It is advantageous to impregnate cotton-covered coils after winding; taping may increase internal temperature 15° C. An improved type of standard resistance coil is now used. Reform is suggested in the method of specifying resistance of conductor rails; resistance of steel rails seems to vary directly, and temperature coefficient inversely, with total impurities. Research on heating of buried cables is well in hand; temperature records are to be taken on actual feeders in various districts. Emission of positive electricity from metals appears to commence at 1000°–1400° C. For the Geodetic Survey of India, an apparatus has been built to measure electrically air temperature at various heights. Revised specifications for bayonet lamp-holders will soon be issued. Measurements have been made on a number of sparking plugs and taps. R. E. N.

1475. *Longitudinal Vibration of Wires.* **G. A. Lindsay.** (Phys. Rev. 3. Ser. 2. pp. 397–438, June, 1914.)—Describes experiments to determine the variations, under changing conditions, of the period and damping of longitudinal vibrations in wires of copper, steel, phosphor-bronze, and platinum-iridium. The following results were obtained:—(1) The modulus is found to be constant with small loads, but (except in the case of copper which shows a constant modulus until the elastic limit is very nearly reached) for greater loads it decreases with increasing load although the wire is still well within the elastic limit. In this latter region the frequencies for small amplitudes are found to be given by an equation of the form

$$n=(1/2\pi)\sqrt{g[a(1+ha)+2\beta e]/M},$$

where h is a small constant depending on the temperature changes in the wire during vibration, and e is the "elongation" (or instantaneous recovery) of the wire for mass M. This "elongation" is the distance of the lowest point of the loaded wire from that point to which it tends to return at the instant of release owing to the elastic forces called out by the distortion. It is found that the variation of e with temperature is negligible (except for Cu in which it has to be allowed for), and that e is independent of the length of time during which the wire has been loaded. Subsidiary experiments showed that the relation between M and e may be represented by the equation $M = \alpha e + \beta e^3$, where α and β are constants for a given wire. (2) The dynamic modulus is found to be always larger than the static modulus, this difference being explained as the result of a large after-effect, the greater part of which disappears very rapidly after the removal of load. (3) The frequency decreases with increase of amplitude for Cu and Pt-Ir. The variation is exceedingly small for phosphor-bronze, and zero in the case of steel. (4) The log. decrement is found to vary with the amplitude, this variation being, in the case of copper, very nearly proportional. The variation is not of such a character as to indicate that damping is due to internal friction.

J. W. T. W.

1476. *Stress Measurements on Board Ships.* **Siemann.** (Zeitschr. Vereines Deutsch. Ing. 58. pp. 1161–1169, July 18, 1914.)—The importance of determining static and dynamic stresses in ship members under all conditions is widely recognised and acted upon, but prevailing methods of calculating such stresses are of uncertain accuracy. To supplement existing knowledge, a series of stress measurements were made on ships at sea. Biles' method is said to be unsuitable for use on merchant vessels owing to the great measuring length involved. The Martens mirror extensometer apparatus requires a measuring length of 200 mm. or even less. Records of the mirror movement are obtained by a motor-driven film camera with strongly magnifying tele-objective. The whole apparatus can be erected even in confined situations; the method of using the apparatus is described and illustrated, and its errors and limitations are discussed. Numerous records taken on various parts of various vessels are reproduced and their significance is discussed. Special attention is devoted to the strength of riveted joints and to the effect of heavy seas. It appears that stresses due to wave-bending moment are much smaller than generally supposed; many failures are due to purely local stresses or to fatigue in the metal. Bow and stern must be built yet lighter to attain the ideal of a beam of uniform strength. The qualitative and quantitative results obtained lead the author to contend that important improvements in naval architecture would follow extended research along these lines. R. E. N.

1477. *Determination of Time by Means of a Clock.* **G. Beauvais.** (Comptes Rendus, 159. pp. 18–20, July 6, 1914.)—The paper embodies the results of an investigation made upon a Reifler pendulum in the Paris Observatory working at constant pressure and with electrical contact, to find the relationship between the pendulum oscillations and their registration by the mechanism of the clock. For this purpose the Abraham photographic chronograph was employed. It was found that the chronometer was only accurate to 1/100th of a second, but that the pendulum movement itself was accurate to 1/1000th of a second when an electrical mode of registration was employed. Specimen curves are given in the paper. H. H. Ho.

1478. *Measurement of the Correction due to Pressure on the Period of a Physical Pendulum.* **T. Takamine.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 265-268, April, 1914.)—The present note is an outcome of preliminary experiments made to test Stokes' correction to the period of oscillation of a physical pendulum due to the pressure of the surrounding gas, viz., $Ap + B\sqrt{p}$, where p denotes the pressure, A and B being constants. The results obtained are also compared with those reported by the Danish Geodetic Committee in 1913. The pendulums used were of the v. Sterneck form hung in thick metal cases, the pressure correction being arrived at by changing the pressure with a pump and observing the corresponding change of the oscillation period. The pressure was measured by a mercury manometer with closed end. On plotting the observed values they were found to fall fairly well on the curve given by Stokes' formula. The actual numbers differ from the Danish, but this may be attributable to the difference in the form of the pendulum bob, etc. The so-called vacuum correction for reducing pendulum observations made at ordinary pressure was found to be but a rough approximation. H. H. Ho.

1479. *Ratio of Periods of Two Pendulums.* **P. Le Rolland.** (Comptes Rendus, 159. pp. 166-169, July 13, 1914.)—Lippmann has previously given a method by which a comparison may be made of the periods of oscillation of two pendulums. The present paper describes a simple way in which the method may be carried out, and it is shown that the method possesses advantages over the method of coincidences usually employed. The principle of the method is to determine the numbers of oscillations n and n', and the fractions of an oscillation a and a', made by the pendulums between any two instants. The ratio of the periods is thus $(n' + a')/(n + a)$. The fractions a and a' are obtained by comparing the phases at the two instants. To determine the phase, a photograph is taken, by means of an electric spark, of an index fixed to each pendulum. At the same time, the indexes are photographed by means of a source of light whose duration is the same as the period of oscillation. Thus the displacement a at the moment when the spark takes place, and the amplitude a_0 are determined. The phase ϕ is thus given by $\sin \phi = a/a_0$. A great advantage of the method is that its application can be rendered entirely automatic. A clockwork mechanism controlling the electric sparks can be adjusted so that the interval between the sparks corresponds exactly to some definite number of oscillations of one of the pendulums. Discussion of the sources of error shows that it is necessary to have the planes of oscillation and the photographic plate accurately parallel. This can be secured in a simple manner, but it is possible to eliminate all error. With this method the periods of, *e.g.*, two seconds-pendulums can be compared in a few minutes with an error of at any rate not more than 1 in a million, whereas the method of coincidences would require several hours. This shortened period of observation has distinct advantages, for it eliminates disturbing effects and allows the variations with time of the period of oscillation to be followed. The author has been able to show in this way that all the knife-edge pendulums he has studied show a systematic diminution of the period as the oscillations are damped, the variation being due to the cylindrical form of the knife-edges. A. W.

1480. *Atomic Structure.* **A. van den Broek.** (Nature, 93. pp. 241-242, May 7, 1914.)—In reply to Nicholson [Abstract No. 477 (1914), and Ibid. p. 630, Feb. 5], van den Broek cites and discusses in detail varied experimental evidence in support both of Bohr's theory of atomic constitution generally, and of his own hypothesis, accepted by Bohr as one of his fundamental assumptions, that the nuclear charge of a Rutherford atom is equal to the atomic number. **J. W. Nicholson.** (Ibid. pp. 268–269, May 14, 1914).—In reply to van den Broek, Nicholson observes that his contention was that van den Broek's hypothesis is fundamentally correct in principle, but inconsistent with Bohr's theory in its present form. Soddy and Fajans' recent generalisation of this periodic table [Abstract No. 170 (1914)], against which mathematical considerations cannot be raised, tends to support van den Broek, but does not show identity between the nucleus charge and the tabular place; the latter might differ constantly from the former by, say, 1 or 2. If completely correct, then Bohr's theory cannot be modified to account for Röntgen-ray spectra. Moreover astrophysical spectra and Bourget, Buisson and Fabry's application of their interference method to a nebula line [Abstract No. 140 (1914)], show that very simple elements can exist in which the atomic number differs from the number of electrons, so that van den Broek's hypothesis cannot be a complete principle, although perhaps satisfactory for the stable terrestrial elements. Bohr's theory is not the only possible explanation of Moseley's results. The author will shortly publish a simpler one, obtained by more ordinary dynamics, which, by attaching a definite structure to the nucleus, accounts for other phenomena such as the velocity of emitted α-particles. It differs only in detail from van den Broek's hypothesis. Mathematically, the only possibility of coplanar rings is the case in which bound electrons *do not repel* each other, a supposition in complete contrast with the present form of Bohr's theory. Many physicists have not yet realised that the wave-length from a ring depends fundamentally, not on the radius alone, but on the angular velocity, the frequency being of the order c/w, where c is the velocity of light, and w the frequency of vibration of the ring about its steady rotation. A ring of *any* radius can give any wave-length, with proper angular velocity. So also can any portion of a structural nucleus, and the Röntgen rays may come from the nucleus. Bohr's mathematics show that in his theory also the wave-lengths are determined by the order of c/w, and not in any fundamental sense by the radius. G. W. DE T.

1481. *Einstein's Gravitational Field and the Electromagnetic Field of Maxwell-Lorentz.* **T. De Donder** and **O. De Ketelaere.** (Comptes Rendus, 159. pp. 23–27, July 6, 1914.)—Mathematical. E. H. B.

1482. *Relativity Principle and Intra-atomic Energy.* **G. Le Bon.** (Comptes Rendus, 159. pp. 26–27, July 6, 1914.)—A comparison of Einstein's theory and the author's views as set forth in his *L'Evolution de la matière.* E. H. B.

1483. *Relativity Principle.* **R. Hiecke.** (Deutsch. Phys. Gesell., Verh. 16. 12. pp. 569–576, June 30, 1914.)—Discusses the difficulties in the way of the acceptance of this principle by physicists. [See Abstract No. 947 (1906).] E. H. B.

1484. *Relativity Principle and Accelerated Motion.* **F. Kottler.** (Ann. d. Physik, 44. No. 5. pp. 701–748, June 19, 1914.)—A highly analytical treatise illustrated with folding tables descriptive of the various motions dealt with. E. H. B.

1485. *Dynamics of Elastically coupled Point-systems.* **E. Schrödinger.** (Ann. d. Physik, 44. No. 6. pp. 916–934, July 8, 1914.)—Mathematical.

1486. *Theory of Long Waves and Bores.* **Rayleigh.** (Roy. Soc., Proc. Ser. A. 90. pp. 324–328, July 1, 1914.)—In the theory of long waves in two dimensions, supposed to be reduced to a steady motion, it is assumed that the length is so great in proportion to the depth of the water that the velocity in a vertical direction can be neglected, and that the horizontal velocity is uniform across each section of the canal. It is found that unless h^2 can be neglected, where h is the elevation of the water at any point of the wave, it is impossible to satisfy the condition of a free surface for a stationary long wave —*i.e.* it is impossible for a long wave of finite height to be propagated in still water without change of type. Since a constant gravity is not adequate to compensate the changes of pressure due to acceleration and retardation in a long wave of finite height, an investigation is made to find what law of force will allow long waves of unlimited height to travel with type unchanged. This is found to be a force varying inversely as the cube of the distance from the bottom of the canal. The generalised form of the relation between velocity and height which must be satisfied in a progressive wave, whether the type be permanent or not, is then given. An application is next made to bores where the uniform levels on the two sides of the variable region are different. Finally, experiments on the formation of bores are described. H. H. Ho.

1487. *On a Typical Form of Isobars.* **T. Terada.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 258–264, April, 1914.)—The form of isobars referred to is a pronounced discontinuity in the direction of the curves of equal barometric pressure as they pass from the Asiatic continent to the ocean in the neighbourhood of Japan. The observed pressures over the ocean are lower than what might have been expected in comparison with the observed values over the neighbouring continent. The author suggests that the phenomenon may be explained by the fact that the frictional effects of the surface of the ocean are not so great as the corresponding effects over the land. Consequently wind velocities over the ocean corresponding with a definite barometric gradient are greater than wind velocities over the land for the same gradient. An application of the equation of continuity to the air over an area extending from sea to land shows that a pressure distribution like that observed may be thereby produced. R. C.

1488. *The International Kite and Balloon Ascents.* **E. Gold.** (Meteorolog. Office Geophysical Mem. No. 5. pp. 65–144, 1913.)—This is a dissertation which obtained the first prize awarded in 1912 by the German Meteorological Society. It is based mainly on the results of soundings of the upper air from Jan., 1904, to Nov., 1909, derived from ascents mostly in Europe of kites, manned balloons, registering balloons, and pilot balloons. The paper is divided into two parts dealing respectively with temperature and wind. Under the former head are treated (1) the average temperature conditions from the surface to 15 or 16 km., (2) the annual variation of temperature at different heights, (3) the diurnal variation of temperature, (4) the stratosphere, (5) temperatures under cyclonic and anticyclonic conditions. The discussion of wind is divided into (1) the connection between the direction of flight of balloons with that of the gradient wind, (2) results for the variation of wind direction and velocity with altitude. The conclusions reached are very numerous, and the work is a standard of reference for students of modern meteorology. It contains many tables of normal values for the upper air. R. C.

1489. *Pressure in Absolute Units.* **W. N. Shaw.** (Monthly Weather Rev. 42. pp. 5–7, Jan., 1914.)—The author discusses the replies to be given to the following three questions: (1) What units of pressure (and temperature) should be adopted in the publication of monthly values of pressure for a *réseau mondial*? (2) What units should be adopted by teachers who wish to interest students of physics in meteorology? and (3) What graduation should be employed for a barometer in order to commend most effectively to the wider public the results of meteorological study? The author finds the answer to all these questions in absolute units on the C.G.S. system. The fact that mean pressure at station level is closely equal to 100 cb. (centibars) in absolute units (so that readings on this scale give pressures as percentages of the mean value) is given weight in supplying the answer to question (3). Attention is drawn to the fact that mm. of mercury form as illogical a measure of pressure as inches, and it is argued that both should be resigned in favour of absolute pressure units. J. S. Di.

1490. *Classification of the Methods of Transition from Rain to Blue Sky.* **W. I. Milham.** (Monthly Weather Rev. 42. pp. 94–97, Feb., 1914.)—During the passage of a low-pressure system to the north of a station certain general weather changes take place. These changes, though having a general similarity, are not all exactly of the same type and the paper suggests certain different classes into which they seem to fall. J. S. Di.

1491. *Meteorological Aspect of the Smoke Problem.* **H. H. Kimball.** (Monthly Weather Rev. 42. pp. 29–35, Jan., 1914. Condensed, with additions and revision, from Smoke Investigation Bull. No. 5. Mellon Inst. of Industrial Research, Univ. of Pittsburg, 1913.)—There is first given a general account of fogs, with their effects upon the limits of visibility, the quantities of soot contained in the atmosphere, etc. The meteorological properties are then discussed. It is pointed out that wet fogs form more readily and are dispersed less easily by sunshine in the smoky air over a city than in the clearer air of the country. Not only do town fogs reduce the number of hours of sunshine received, but the percentage diminution in the intensity of what daylight is received is even greater than the diminution of hours of sunshine. Much evidence is brought forward to show that night minimum temperatures are considerably raised by the presence of a foggy layer, while the day maxima are but slightly affected. Taking six American towns it is found that the minimum temperature averages about 3·6° F. higher, and the range of temperature 4° less, than the corresponding data for surrounding stations. J. S. Di.

1492. *Atmospheric Transparency for Radiation.* **F. E. Fowle.** (Monthly Weather Rev. 42. pp. 2–4, Jan., 1914.)—A table is reproduced from an earlier publication showing the transmissibility of radiation through dry air above Mount Wilson (1730 m.) for different wave-lengths [see Abstracts Nos. 1931 (1913), 482 (1914).] Corresponding figures derived by Rayleigh's theory from the number of molecules in the air are also given. The agreement between the two sets of figures is remarkable. This shows that molecular scattering fully accounts for the loss of radiation in transmission through dry air, but in the case of moist air the same theory does not so fully account for the loss. It is suggested that the formation of ions or nuclei plays some part in the loss in this case. At stations below 1000 m. height there is a third cause of loss in atmospheric dust. If the transmitted radiation be calculated by means of the factors for dry and moist air here put forward, values in good agreement with those obtained by direct measurement will be obtained for stations above this 1000-m. dust-layer. J. S. Di.

1493. *The Gulf Stream.* **M. W. C. Hepworth.** (Nature, 93. pp. 441–443, June 25, 1914. Paper read before the Roy. Geographical Soc., May 21, 1914.)—That wind is the prime cause of all ocean currents is demonstrated by comparison of a map of mean wind with a corresponding chart of currents. By temperature and salinity observations the course of the Gulf Stream can be traced out across the Atlantic eastwards. The effect of the temperature of this stream upon the temperature of the British Islands is traced through the two years 1911 and 1912. When the stream is abnormally active on the American coast its resistance to the Labrador current is carried farther north than usual with the result that its north-easterly branch pursues its course into higher latitudes, while with a weak Gulf Stream the converse occurs. J. S. Di.

1494. *The Floods of* 1913 *in Ohio and Lower Mississippi Valley.* **A. J. Henry.** (Weather Bureau, Bull. Z [117 pp.], Washington, 1913.—A profusely illustrated report on the disastrous floods of March and April, 1913, dealing at length with the meteorological conditions just previous to the catastrophe. L. H. W.

1495. *Experimental Determination of the Earth's Elastic Properties.* **H. G. Gale.** (Science, 39. pp. 927–933, June 26, 1914.)—This paper is a discussion of recent investigations made of the earth's elastic properties. If the earth were a perfectly fluid mass there would be no change of the plumb-line relative to the earth's surface, and the so-called "deflection of the vertical" could not be detected, while if the earth were perfectly rigid the plumb-line would move back and forth, as the positions of the sun and moon vary, by an amount which can be calculated with an accuracy limited only by knowledge of the masses and relative positions of the sun, earth, and moon. Since the earth is partially rigid the excursions of the plumb-line are a certain fractional part of the full computed value, and, after this fraction has been found by experiment, it is possible to compute the rigidity of the earth. The earlier work of Darwin, Paschwitz, Ehlert, v. Rebeur, Kortazzi, Hecker, and Orloff is briefly summarised in the paper. Chamberlain and Moulton, being desirous of securing definite data on the plasticity of the earth on account of its vital bearing on planetary evolution, interested Michelson in the problem, and he carried out a series of measurements using a long horizontal water surface in place of a long pendulum and measuring the changes of level at its ends. Details of this work are very fully described. The earth was found to yield more readily to distorting forces in the N.-S. direction than in the E.-W., a result foreshadowed by Schweydar. It was also found that the maxima and minima of the observed and computed tides occurred almost exactly simultaneously. The mean rigidity of the earth was found to be about $8{\cdot}6 \times 10^{11}$, and the viscosity $10{\cdot}9 \times 10^{16}$ C.G.S. units, being of the order of magnitude for steel. H. H. Ho.

1496. *Further Evidence for the New Physical Theory of the Formation of the Primitive Oceans and Continents.* **E. Belot.** (Comptes Rendus, 159. pp. 89–92, July 6, 1914.)—In a preceding note [see Abstract No. 823 (1914)] the author has shown how the translatory movement of the earth through the primeval nebula produced in the primitive atmosphere a circulation which chilled the

Antarctic and caused there the first aqueous precipitation. Two further causes combined in this cooling effect—namely, the altitude of 3000 m. and the gaseous expansion produced above it, the latter being similar to the cooling effect in the rear of projectiles. The author applies his theory to the alkaline chlorides, iodides, and fluorides, which are volatile between 700° and 800°, and which would exist in the primitive atmosphere as found at present in volcanic emanations. These salts will be precipitated before water, and in consequence the latter will be almost saturated from the commencement. If, on the other hand, Joly's hypothesis be true, that the sea was originally fresh and had acquired its salt by continental lixiviation, then vegetation could not have appeared at the commencement of the primary epoch, owing to the excess of salt in the soil. Several dynamical consequences are drawn from this theory. The Antarctic erosion, as shown by the Weddell and Ross Seas, furnished material for transport by ocean currents and gave rise to barriers, now outlined by continental points, islands, etc., between latitudes 40° and 50° S. in the Atlantic and Indian Oceans, forcing the water to the Pacific which is consequently the most antique ocean. This unsymmetrical water distribution, which in gaseous form was uniform throughout the whole atmosphere, was compensated by a corresponding surface movement so that the continents have oceans for their antipodes. Not only the latter, but also the quantitative relationship is true, viz. that the weight of the oceans equals that of the land above the base level -2520^{m}, and, therefore, in order to build continents above the primitive surface of the earth, the oceans have eroded a weight of material equal to their own. Finally, owing to erosion the more resistant materials remain beneath the primitive oceans, which would explain the greater intensity of gravity and magnetism at sea than upon land. H. H. Ho.

1497. *Motions of the Brighter Stars of Class A in Relation to the Milky Way.* **H. C. Plummer.** (Lick Observatory, Bull. No. 212.)

1498. *Radial Velocities of* 915 *Stars.* (Lick Observatory, Bull. No. 229.)—Gives the results optained at Mount Hamilton and Santiago for the brighter stars of classes F, G, K, and M whose radial velocities appear to be substantially constant. L. H. W.

1499. *Real Motions of* 100 *Stars of Large Proper Motion, whose Radial Velocities have been determined.* **H. C. Wilson.** (Lick Observatory, Bull. No. 214.)

1500. *Preliminary Radial Velocities of* 212 *Brighter Class A Stars.* **W. W. Campbell.** (Lick Observatory, Bull. No. 211. Paper read before the National Academy of Sciences, Washington.)

LIGHT.

1501. *Type-reading Optophone.* **E. E. Fournier d'Albe.** (Roy. Soc., Proc. Ser. A. 90. pp. 373–375, July 1, 1914.)—A modification of the author's "optophone" [Abstracts Nos. 964 (1913) and 337 (1914)], an instrument designed to substitute the sense of hearing for that of sight. In the previous instruments transparent letters 5 cm. high could be read, but by the modifications here described it should be possible, with practice, to read ordinary type. These consist in decreasing the length of the line of intermittent luminous dots which illuminate the letter to the size of ordinary type, using the light to actuate the selenium or antimonite bridge after diffused reflection by the printed surface, and in increasing the sensitiveness of the telephone receiver connected to the bridge, by means of a Brown telephone relay.

T. H.

1502. *Phase Change by Reflection—Primarily in the Ultra-violet.* **O. H. Gish.** (Phys. Rev. 3. Ser. 2. pp. 353–368, May, 1914.)—Following a method essentially that used by Wernicke, thin parallel plates of mica were used in part of the work here described, but certain advantages led finally to the use of thin wedge-shaped plates of glass, the method adopted in the latter case being that used by Drude and by Koenigsberger and Bender [Abstract No. 1605 (1908)]. The substances investigated for phase change were silver, fuchsin, Doppel-grün, crystal-violet, cyanin, eosin, and aniline-orange. In the observations with mica a thin mica plate coated, except for a central strip, with the substance to be tested, was so mounted that a source of light was focused by means of a quartz lens upon the mica at an angle of incidence of about 2·5°. Then, by means of another quartz lens an image of this plate by the reflected light was cast on the slit of a 4-ft. Rowland grating spectroscope. With a Nernst glower and exposures of 8 hours' duration it was found that the limit into the ultra-violet to which observations could be extended was 340 $\mu\mu$. Using thin glass wedges selected from glass cover-slips a discontinuous spectrum could be employed. For this a copper arc was used, and the glass plate, diaphragmed down to an aperture of 4 by 10 mm., mounted in place of the spectroscope slit. By means of two quartz lenses and a total-reflection quartz prism an image of the arc was formed on the plate, the light being incident as before at an angle of about 2·5°. When properly adjusted all the images of the set of bands obtained were found well defined. Photographic records were obtained upon films of such length as to include the first order spectrum and a large portion of the ultra-violet region in the second order. The displacement of the bands, which serves as a measure of the phase-change relative to glass, was measured with a micrometer microscope. The photographs taken for silver on mica showed a relative shift of about three-tenths of a band at 580 $\mu\mu$, decreasing slowly with decreasing wave-length to about 442 $\mu\mu$, where the two sets of bands seem to coincide. The shift with silver on glass was practically the same as for mica, except that the position at which the bands coincide seemed to be shifted farther toward the ultra-violet (to about 390 $\mu\mu$). They continued to coincide throughout the transmission region for silver and as far as the photograph showed distinct bands (296 $\mu\mu$). The measurements on fuchsin show a decreasing phase-change for decreasing wave-length until between 420 and 440 $\mu\mu$, where coincidence, or at least a minimum phase-change, is observed. Beyond this point the phase-change suddenly mounts to its highest value, after which a gradual decrease is observed to 280 $\mu\mu$, where its value is 0·27 wave-length. It was found that between 440 and 820 $\mu\mu$ fuchsin was practically as transparent as glass. The abrupt change in phase difference at 420 $\mu\mu$ from zero to half a wave-length probably arises from the fact that the refractive index of fuchsin, which is less than that of glass at 425 $\mu\mu$, rises above it between 425 and 410 $\mu\mu$. The value of the phase-change at the surface of Doppel-grün goes through two minima between 600 $\mu\mu$ and 280 $\mu\mu$, one minimum being at about 520 $\mu\mu$, the other at about 390 $\mu\mu$. Transmission maxima were found between 496 and 487 $\mu\mu$ and between 389 and 340 $\mu\mu$. Results similar in general character were obtained with the other substances dealt with, and all results are tabulated and graphed. A. W.

1503. *Measurement of Refractive Index of a Drop of Liquid.* **F. E. Wright.** (Washington Acad. Sci., Journ. 4. pp. 269–279, June 4, 1914.)—The refractive index is the most important optical constant with which a petrographer has to do, since its determination on a single mineral grain enables him practically to identify the mineral within narrow limits. The determination of the refractive indices of irregular mineral grains measuring 0·01 mm. in diam. is best accomplished by means of the immersion method, in which the refractive indices of the mineral grain are compared with that of the liquid in which it is immersed. In the present paper the measurement of the refractive index of a single drop of liquid is considered in some detail. The accuracy of the standard methods (with the exception of the Abbe refractometer methods) for this purpose is discussed, and certain new modifications are suggested which render possible the application of such methods to a single drop of liquid. The use of a diffusing screen in front of monochromatic light sources is emphasised. A new type of hollow prism is suggested which has proved satisfactory and convenient, and with which measurements (accurate to the fourth decimal place) can be made either by a method of auto-collimation or by the minimum deviation method or by Gifford's method. The prism consists of two optically plane, parallel glass plates (10 × 20 × 2 mm.) held in place against a 80° glass prism (10 × 10 mm.) by means of a brass clamp. The liquid is introduced between the glass plates and is held in place by capillarity. A semicircular notch in the middle of the edge of the glass plates prevents the liquid from creeping up along the ridge formed by the glass plates, and thence into the prism support. The use of a cover of specially prepared tin-foil on a drop of liquid to be measured on the Abbe-Pulfrich crystal total-refractometer is suggested as a satisfactory method for obtaining the phenomena of grazing incidence even on a thin film of liquid. Five new methods are also described for measuring the refractive index of a drop of liquid with the petrographic microscope. Of these methods, method 5, which requires solely a plane-parallel glass plate of high refractive index, with one edge bevelled at an angle of 60°, is the simplest and most convenient. With it the refractive index of the liquid can be easily measured to the third decimal place, an accuracy which is sufficient for all determinative purposes. The other methods are interesting and of about the same order of accuracy, but they are less simple and therefore less useful. The methods of Clerici, Viola, Piltschikow, Smith and Clay are presented briefly, but they are also without exception less simple and less accurate than method 5, which is accordingly recommended, especially as the cost of the glass plate required is slight, and the amount of liquid necessary for measurement is a very small drop.

It is of the greatest importance to the science of petrology that the materials, of which it treats, be studied in a quantitative way; the refractive indices of the rock-making minerals, many of which are isomorphous mixtures, are fundamental optical constants which should be measured and included in every detailed description of a rock. A. W.

1504. *Autostereoscopic Photography.* **E. Estanave.** (Comptes Rendus, 159. pp. 164–166, July 13, 1914.)—The author has previously shown [Abstract No. 488 (1909)] that the autostereoscopic plate, which has opaque lines ruled on the surface of the glass which does not carry the sensitive film, allows photographs to be obtained giving to direct vision the sensation of stereoscopic relief. The present paper deals with a similar effect when only a single image of the object dealt with is available. A. W.

1505. *Theory of Lippmann Colour Photography.* **K. Försterling.** (Phys. Zeitschr. 15. pp. 225–234, March 1, 1914.)—A mathematical study of the theory of Lippmann photography on the basis of the variation of the dielectric constant in the various layers of the emulsion. It is shown that a perfect rendering of mixed colours is theoretically impossible. Most natural colours consist of broad bands in the spectrum. Of these bands the maxima are rendered chiefly. Thus the colours are more brilliant than true to the original. E. E. F.

1506. *Circulation of the Ether in Rotating Interferometer.* **G. Sagnac.** (Journ. de Physique, 4. Ser. 5. pp. 177–195, March, 1914.)—A paper dealing more fully with the author's rotating interferometer described previously [Abstract No. 216 (1914)]. Interference fringes are obtained with two luminous beams propagated in opposite directions round a closed circuit surrounding an appreciable area. When the whole apparatus is rotated, first in one direction and then in the other, photographs of the fringes taken on the same plate exhibit a relative displacement proportional to the width of the fringes and representing a definite phase-difference characteristic of the effect of the motion of the circuit as a whole. This phase difference is quite distinct from any effect due to the accidental or elastic movements of the optical arrangements, and is due to the movement of the circuit as a whole with respect to the ether of space. The effect is just as if an ether wind blew in the immobile circuit in the opposite sense to the direction of propagation and diminished the velocity of the light-waves. Theory is given showing how the effect depends on the area of the circuit, the velocity of rotation, etc., and the experimental measurements are in agreement with results calculated on the supposition that the ether is an immobile fluid transmitting luminous waves with an invariable velocity. Thus this rotating optical effect can be regarded as an effect, of the first order, of motion with respect to the ether, and confirms its existence. A. W.

1507. *Electromagnetic Emission Theory of Light.* **J. Kunz.** (Phys. Rev. 3. Ser. 2. pp. 464–475, June, 1914.)—This is an endeavour to found a new theory of the physical universe which shall avoid some of the difficulties and drawbacks of the theory of relativity. This alternative theory agrees with that of relativity in many features, but gives an entirely different aspect of the world. This electromagnetic emission theory of light is a compromise between the emission theory and the wave theory. Each electric charge is supposed to be surrounded by an electromagnetic field residing in the medium, which field itself forms the mass of the charge. Thus instead of having a continuous medium, ether, we have as many media as there are electric charges. Each individual electromagnetic field extends throughout the universe, but is essentially concentrated in the immediate neighbourhood of the electron. The theory is worked out mathematically and applied to the change of mass with velocity, etc. E. H. B.

1508. *Path of Light in Rotating Solid.* **E. M. Anderson.** (Roy. Soc., Edinburgh, Proc. 34. pp. 69–76, 1913–1914.)—A mathematical calculation of the path of a light ray in a rotating homogeneous and isotropic solid, the analysis being based on the Fresnel formula that the ether being fixed, the medium imparts $(\mu^2 - 1)/\mu^2$ of the amount of its own motion to the advancing disturbance; this conclusion being also a necessary consequence of the modern theory of relativity. Within the limits considered the curve is part of a circular helix. E. H. B.

1509. *Infra-red Dispersion of Diatomic Crystals.* **W. Dehlinger.** (Phys. Zeitschr. 15. pp. 276–283, March 15, 1914.)—Nernst's combination of Einstein's and Debye's formulæ involves two frequencies characteristic of diatomic crystals. These frequencies may be expected to be proportional to the square roots of the masses of the two constituent atoms. The author does not agree with the five rest-ray frequencies introduced by Born and v. Kármán, but believes there is only a single rest-ray frequency. He calculates the dispersion of a diatomic crystal built on Madelung's model, and arrives at a formula identical with that of Ketteler and Lorentz, which is based on simply oscillating, independent charges. E. E. F.

1510. *Radiation of a Point Source close to the Surface separating two Media.* **L. Mandelstam.** (Phys. Zeitschr. 15. pp. 220–225, March 1, 1914.)—If the source of light is immersed in a rare medium, but very close to its surface of separation from a denser medium, the light in the latter is no longer confined to a cone, but spreads in all directions. Conversely, if a convergent beam of light falls through glass into a fluorescent liquid, there is a fluorescent spot if the focus is close to the liquid, even though the angle of incidence is greater than the critical angle. The absorbing layer does not, however, exceed in thickness the wave-length of the incident light. The author investigates the electromagnetic theory of this effect, and arrives at a formula which supplements that of Sommerfeld. E. E. F.

1511. *Appearance of the Eye when subjected to an Intense Beam of Ultraviolet Rays.* **G. Michaud** and **J. F. Tristan.** (Archives des Sciences, 37. pp. 345–346, April, 1914.)—Bugnion, in the course of a study of the eyes of nocturnal insects, has advanced the following hypothesis: Perhaps it may be supposed that certain obscure rays, by the effect of chemical action, are transformed into visible rays when they are reflected at the base of the eye. The eyes of nocturnal animals give under certain circumstances a very beautiful luminosity, so that by comparison the lamp which illuminates them only appears to glow feebly. The authors have observed an effect which, if it does not positively confirm this hypothesis, seems nevertheless to be in its favour. If the eye of a cat is examined in daylight, it is seen that the pupil always stands out black on the clear and generally greenish ground of the iris; variations of intensity of the illumination affect only the dimensions and shape of the pupil. If, however, the observation is repeated in a completely dark room, allowing to fall on the eye of the cat a beam of sunlight passed through a Zeiss uviol filter, the pupil is seen to stand out in luminous green on the purplish black ground of the iris. The same results have been obtained with the eye of a dog and with a human eye. In each case the light emitted by the pupil was of a decided green colour, that from the human eye apparently being the most intense of the three. This curious appearance of the eye observed in ultra-violet light is probably caused, first, by the fluorescence of one of the media inside the eye, perhaps the purple of the retina, and secondly by a very strong absorption of the ultra-violet light by the iris, the pigment of which plays, in this case, the same protective part as the pigment of the skin. The authors have previously shown that when photographed with ultra-violet light of wave-length λ3160 to λ3260, the skin of a white man appears just as black as that of a negro or an Indian. A. W.

1512. *Fresnel's Reflection Formulæ.* **A. Wiegrefe.** (Ann. d. Physik, 44. No. 2. pp. 283–288, May 12, 1914.)—Mathematical paper dealing with the reflection and refraction formulæ for complex angles of incidence and refraction.
E. H. B.

1513. *Ponderomotive Effects of Circularly Polarised Light.* **K. Schaposchnikow.** (Phys. Zeitschr. 15. pp. 454–455, May 1, 1914.) **H. Busch.** (Phys. Zeitschr. 15. pp. 455–457, and pp. 457–458, May 1, 1914.)—Mathematical discussions of this subject. [See Abstracts Nos. 1672 (1910) and 849 (1914).]
E. H. B.

1514. *Concave Diffraction Gratings.* **G. Guglielmo.** (Accad. Lincei, Atti, 23. pp. 232–237, Feb. 25, 1914.)—Describes several new methods of mounting and working concave gratings. E. E. F.

1515. *Pressure of Light on a Perfectly Conducting Semi-plane.* **P. S. Epstein.** (Deutsch. Phys. Gesell., Verh. 16. 10. pp. 449–456, May 30, 1914.) —A mathematical treatment obtaining expressions for the pressure, the vibrations being taken successively parallel and perpendicular to the edge.
E. H. B.

1516. *Symmetry of Electromagnetic Tensors.* **M. Abraham.** (Ann. d. Physik, 44. No. 4. pp. 537–544, June 4, 1914.)—With reference to a recent paper by K. Schaposchnikow [see Abstract No. 849 (1914)], as to the ponderomotive couple existing at a source of light, the present author discusses mathematically the question as to the symmetry of the electromagnetic world-tensors concerned. E. H. B.

1517. *Lecture Experiment on the Irrationality of Dispersion.* **S. P. Thompson.** (Phys. Soc., Proc. 26. p. 154, April, 1914.)

1518. *Theory of the Grating.* **W. v. Ignatowsky.** (Ann. d. Physik. 44. No. 3. pp. 369–436, May 26, 1914.)—Mathematical.

1519. *The Dispersion of a Light Pulse by a Prism.* **R. A. Houstoun.** (Roy. Soc., Proc. Ser. A. 90. pp. 298–312, May 28, 1914.)

1520. *Types of Abnormal Colour Vision.* **L. Bell.** (Amer. Acad., Proc. 50. pp. 3–13, May, 1914.)

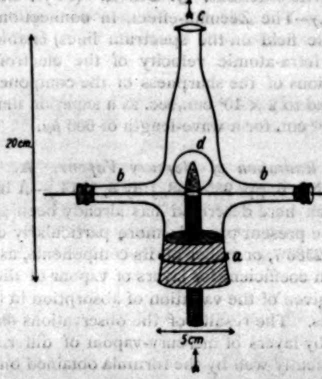
1521. *Theory of Rotational Optical Activity in Isotropic Media.* **G. H. Livens.** (Phil. Mag. 27. pp. 994–1009, June, 1914.)—In some recently published papers [Abstracts Nos. 1815 (1913) and 1058 (1914)] the author, starting from a suggestion originally made by Lorentz, has given indications towards a new form of the electron theory of the optical rotatory power in isotropic media. The results obtained are in such close agreement with the experimental facts that there can be little doubt as to the correctness of the fundamental assumptions on which they are based. The object of the present paper is to give as complete a statement of the theory as possible, in the hope that it may lead to further experimental investigations of its appropriateness. The general formulæ obtained, although rather complicated, are nevertheless sufficiently general to contain an effective explanation of all the apparent anomalies in the behaviour of the intrinsic optical rotatory power of isotropic media. This theory, which makes the rotative power depend essentially on the ordinary dispersion and absorption in the medium, would indicate large variations of this rotative power consequent on any variation of condition which alters to any appreciable extent the usual dispersive and absorptive properties of the medium. **G. Bruhat** (Ibid. 28. pp. 302–304, Aug., 1914). A. W.

1522. *Speed of Series Electrons.* **J. Stark.** (Phys. Zeitschr. 15. pp. 265–267, March 15, 1914.)—The Zeeman-effect, in connection with the "Stark-effect" (of an electric field on the spectrum lines) enables us to assign an upper limit to the intra-atomic velocity of the electrons emitting series spectra. Considerations of the sharpness of the components and the atomic thermal agitation lead to 2×10^5 cm./sec. as a superior limit. This gives an amplitude below 10^{-10} cm. for a wave-length of 600 $\mu\mu$. E. E. F.

1523. *Resonance Radiation of Mercury Vapour.* **A. v. Malinowski.** (Ann. d. Physik, 44. No. 6. pp. 935–968, July 3, 1914.)—A brief account of the results of the research here described has already been given [see Abstract No. 222 (1914)]. The present paper is more particularly concerned with the breadth of the line $\lambda 2536{\cdot}7$, or rather of its components, as well as the variation of the absorption coefficient for layers of vapour of different thicknesses. Particulars are also given of the variation of absorption in a magnetic field for different air-pressures. The results of the observations on the absorption of resonance radiation by layers of mercury-vapour of different thicknesses can be represented sufficiently well by the formula obtained on the supposition of an exponential intensity distribution in emission and absorption lines (after Rayleigh). The investigations in a magnetic field show that the resonance lines $\lambda 2536{\cdot}7$, as well as the absorption lines of the same wave-length consist of several sharp and well-defined components. Calculation based on Rayleigh's formula gives for the breadth of the components a value which differs very little from the theoretical (about $2{\cdot}3 \times 10^{-4}$ Å. unit). An approximate calculation of the damping coefficient leads to a very small value ($1{\cdot}2 \times 10^{-18}$), which is only four times as great as Planck's value. The molecules participating in the resonance probably make up only a small fraction of the total number. With increased air pressure in the absorption chamber from about 0·003 mm. up to atmospheric pressure, the components of the absorption lines broaden more and more, until finally they merge into a single line. In a very high vacuum, obtained by the use of liquid air, the components are sharper and better isolated from one another. The structure of the lines appears to be uninfluenced by the variations of the pressure. A. W.

1524. *Arc and Spark Spectra of Copper in International Units.* **K. Hasbach.** (Zeitschr. wiss. Phot. 13. pp. 399–430, May, 1914.)—Describes wave-length measurements of the arc and spark spectra of copper, the 6·84-m. radius Rowland concave grating of Bonn University being used. Tables are given of the results, together with those of Kayser and Runge and of Exner and Haschek for comparison. Tables are also given of lines in the first and second subordinate series and in the principal series. A. W.

1525. *Use of Uncondensed Spark for Production of "Flame Spectra."* **A. Harnack.** (Phys. Zeitschr. 15. pp. 578–581, June 1, 1914.)—A new method is described in which the uncondensed spark between Pt electrodes may be utilised to obtain a "spark-flame," which will yield flame spectra of substances introduced into it. The apparatus is shown in the accompanying diagram. The Pt electrodes pass through the side-tubes *b*, *b*, and just reach the top of a porcelain tube passing through the cork at the bottom. When the electrodes are connected to an induction coil provided with a mercury break (frequency 50 to 60) and a strong blast of air is sent through the porcelain tube, a so-called spark-flame is obtained at the top of the tube. If the air blast is charged with a metallic salt solution the spark-flame becomes coloured as in the case of a Bunsen flame, or the metallic salt may be introduced in powder form, giving a greater concentration. The flame thus obtained gives an intense source of light, exposures of from 2 to 10 mins. yielding very satisfactory spectrograms. An observation window *d* of quartz allows the ultra-violet region to be dealt with. The spark-flame yields a typical flame spectrum, and is very similar to the oxy-hydrogen blow-pipe flame. The spark-flame can be operated with different gases. With hydrogen a flame is obtained similar to the chlorine-hydrogen flame; both are oxygen-free flames, but the electrical conditions of the one give rise to essentially different phenomena. A comparison was made of the spectra of the alkaline earths given by the spark-flame operated with oxygen and with hydrogen, with those of the oxy-hydrogen flame and the chlorine-hydrogen flame. Photographs are reproduced, and the results discussed. Further research on these lines is in progress. A. W.



1526. *Optical Resonance of Sodium Vapour under Excitation of a Single D-line.* **R. W. Wood** and **L. Dunoyer.** (Comptes Rendus, 158. pp. 1490–1492, May 25, 1914.)—The experiments described were undertaken with a view to ascertaining whether it was possible to obtain luminous sodium vapour emitting only one of the two D-lines. The phenomenon of surface resonance was utilised, and either D_1 or D_2 light was allowed to fall on the bulb containing the Na-vapour, the method of separating the two rays being that previously described by Wood [Abstract No. 1063 (1914)]. Using the more intense D_2 light, it was found that the surface resonance light only emitted the ray D_2 and not D_1 at all. It appears extremely probable that the resonance excited by D_1 should not contain D_2. This is more difficult to verify an account of the smaller intensity of the ray, and the necessity of maintaining constant, during all the time of exposure, the temperature of the quartz block employed ; it is also necessary to avoid too great a blackening of the bulb. Some interesting results were also obtained of the way in which the relative intensity of the resonance rays varies when the quantity of sodium in the flame is altered. [See also Abstracts Nos. 299 (1906) and 859 (1914).] A. W.

1527. *Separate Excitation of the Centres of Emission of the D-lines of Sodium.* **R. W. Wood** and **L. Dunoyer.** (Phil. Mag. 27. pp. 1018–1025, June, 1914.)—Deals with the same experiments as the paper dealt with in the preceding Abstract, but gives greater detail. Photographs are reproduced. [See also Abstracts Nos. 299 (1906), 1239, 1240, and 1250 (1914).] A. W.

1528. *The So-called Cyanogen Bands.* **W. Grotrian** and **C. Runge.** (Phys. Zeitschr. 15. pp. 545–548, June 1, 1914.)—Experiments are described which show that the so-called cyanogen bands at λ3360, λ3590, λ3883, λ4216, and λ4606 are strongly generated in a long nitrogen arc light, when neither cyanogen nor carbon is present. These bands are therefore to be attributed to nitrogen. This conclusion was reached as the result of a number of different experiments, and it is shown that it is not in disagreement with any results known up to the present. [See Abstract No. 539 (1909).] A. W.

1529. *Repartition of Energy in the D-lines of Sodium.* **R. Ladenburg** and **F. Reiche.** (Comptes Rendus, 158, pp. 1788–1790, June 15, 1914.)—In his researches on the photometry of coloured flames, Gouy has discovered laws according to which the brightness of narrow lines varies with the thickness and density of the vapour. These laws are in agreement with conclusions drawn from the electronic theory of dispersion developed by the present authors [see Abstract No. 1641 (1913)]. For vapours in a very dilute state, there is a perceptible though small difference between the observations of Gouy and the author's theory. This difference can be explained by supposing that the Doppler-effect results in the repartition of energy of the D-lines in the case of dilute vapours according to the theory of Rayleigh. From the curves given it is seen that the influence of the Doppler-effect is at first to diminish the experimental values with respect to the theory of dispersion, but little by little the values pass into almost exact agreement with the dispersion theory. From this and other experiments on the velocity of the luminous centres and the damping of their oscillations, it is concluded that in very dilute vapours the coefficients of emission and of absorption of the D-lines follow as a first approximation the function of Rayleigh; but as the density of the vapour increases, it is found that the function of the theory of dispersion tends more and more to the repartition of energy of the D-lines, and finally predominates. A. W.

1530. *Ultimate Lines of Elements in Different Sources of Light.* **A. de Gramont.** (Comptes Rendus, 159. pp. 5–12, July 6, 1914.)—In previous work [Abstract No. 1844 (1907)] the author has shown that the ultimate lines of elements resist the effect of self-induction in the condensed spark, and that they are found in the arc, in the envelope of the blue cone of the Bunsen burner, in the oxy-acetylene blow-pipe flame and also in the oxy-gas blow-pipe flame. They comprise the lines which are spontaneously reversible, and disappear the last when the quantity of the element in the light source tends towards zero. The results of Hartley and Moss [Abstract No. 1696 (1912)] do not always give the ultimate lines in the sense here considered, since their observations were made by the method of decreasing the time of exposure, which is not the same as decreasing the quantity of the element present in the source of light. The effect of the temperature of the light source is dealt with, and from the study of the spectra of several substances the following laws have been deduced. Up to the present no exceptions to these laws have been discovered. (i) If in sources at different temperatures the lines of an element do not preserve the same sensibility, the ultimate lines will be, in all cases, comprised among a very small number of lines, having great sensibility in the condensed spark. (ii) The lines of max. sensibility are correspondingly less refrangible according as the temperature (or the energy) of the source is lower. A typical example of lines whose sensibility varies with the temperature of the source is furnished by the alkaline earth metals, which each present three lines of great sensitiveness in the different sparks and in the arc, lines which exhibit exactly similar characteristics from one spectrum to another. The wave-lengths are as follows:—

	g′.	H.	K.
Ca …………………	4226·9	3968·6	3933·8
Sr …………………	4607·5	4215·7	4077·9
Ba …………………	5535·7	4934·2	4554·2
Ra …………………	4826·1	4682·4	3814·6

The results for Ra are those of Runge and Precht. For the four metals the lines H and K are the strongest in the spark; in the arc all three lines have about the same intensity, though different numbers for the intensities have been given by different observers. The lines *g′* appear alone in the total flame of the Bunsen burner, whether observed photographically or visually. In the spark the lines H and K are the ultimate lines, K being the last to disappear; but *g′* is of great sensibility, only slightly less than that of the others. A transformation of the same kind, though less marked, is seen in the case of the triplets of Cr and Mn. [See also Abstract No. 1527 (1912).] A. W.

1531. *New Method for Study of Spark Spectrum.* **C. de Watteville.** (Comptes Rendus, 159. pp. 80–82, July 6, 1914.)—The apparatus used was similar in general principle to that previously employed by the author for the study of phosphorescence [see Abstract No. 1879 (1906)]. Modifications were made as follows: An Al disc carried at opposite ends of a diameter two metal points which could pass very close to two other points P and P′, which were fastened to the ends of an insulating rod. One of the plates of a condenser of large capacity, worked by a transformer of the type used by Hemsalech, was connected to the point P. The other plate was connected to one of the electrodes E, between which passes the spark to be studied. The second electrode was connected to the point P′. When the disc rotates and the points pass P and P′, two small sparks pass and thus allow the condenser to be discharged, the principal spark taking place behind the disc. The spark is viewed through an opening D in the disc, and the angular distance of this from the fixed points determines, in conjunction with the speed of the disc, the length of time between the passage of the spark between the electrodes E and the time of observation. By means of a lens divided into two halves along a diameter, the halves being slightly separated from one another, two small images of the spark are projected on to the disc. The shape of the opening D is such that one of these is viewed before the other, but the duration of observation of each image is the same. A single lens on the other side of the disc is used to project the two images on to the top and bottom halves of the slit of a spectroscope, so that two photographs are obtained on the same plate, the two spectra corresponding to different periods of observation after the passage of the spark. With the apparatus described the spark can be observed 1/8000 sec. after the discharge has taken place, a worm and wheel being used to determine the speed of the disc, which can make 4000 revs. per min. A. W.

1532. *Arc and Spark Spectra of Helium.* **J. Stark.** (Deutsch. Phys. Gesell., Verh. 16. 10. pp. 468–474, May 30, 1914.)—For some time past the author has been investigating the difference between the arc and spark lines of elements in their canal- and kathode-ray emission, and has shown that the arc lines are emitted by the positive singly-charged atomions of the elements, while the spark lines are emitted by positive atomions doubly- or multiply-charged [see Abstracts Nos. 982, 1283, 1960 (1913), 75 (1914).] In the present research the following results were obtained: (1) The line of wave-length 4686 Å., which has up to the present been regarded as a hydrogen line, is emitted strongly from the positive column of the oscillatory spark in helium free from hydrogen, so it must be assigned to helium. (2) The two known series systems of helium behave in the positive column, in kathode- and in canal-rays, like arc lines. (3) The new helium line λ4686 behaves in the positive column, in canal rays, like a spark line. (4) The peculiarities of the emission of the arc and spark spectra of helium can be explained by the fact that the former has for carrier the positive singly-charged helium atomion, the latter the positive doubly-charged atomion. A. W.

1533. *Luminous Vapours distilled from the Arc. Spectrum Series.* **R. J. Strutt.** (Roy. Soc., Proc. Ser. A. 90. pp. 364–372, July 1, 1914.)—It is known that mercury vapour distilled away from the arc *in vacuo* remains luminous for some distance away from the region of discharge [see Abstract No. 859 (1913)]. It is now shown how to observe brilliant effects of the same kind from a large number of other metals, including As, K, Cd, Na, Zn, Mg, Ca, Sb, Tl, Bi, Pb, Ag, and Cu. A special form of arc was used, the anode consisting of either a perforated diaphragm or a perforated plug, according to circumstances, at the upper end of a quartz tube wrapped with asbestos paper for opacity. The kathode, at the bottom end of the tube, consisted of a pool of the molten metal under consideration, melted by the heat of the arc.

The luminous vapour issued in the form of a jet from the hole in the anode. The whole apparatus was contained in a bell-jar which could be evacuated by means of a Gaede molecular pump. The appearance and general characteristics of the jet of luminous vapour observed in the case of each of the metals given above are described in detail. It is found that as the luminous vapour moves away from the region of discharge, the rate at which different constituents in the spectrum die out is not always the same. Thus, for instance, both the subordinate series of lines in the sodium spectra die out at the same rate, but the principal series dies out more slowly. The lines belonging to any given series always die out at the same rate, but another series may or may not die out at the same rate as the first. In some cases the glowing vapour distilled from the arc shows a band spectrum. The alkali metals show a continuous band beyond the limit of the subordinate series like that seen in absorption in the hydrogen stars. The present paper deals only with experimental methods of observing the luminous jets of metallic vapour distilled from the arc, and their more obvious features. In a subsequent one will be discussed the effect of an electric field in quenching the luminosity, and the inferences which can be drawn from the observations generally as to the origin of the radiation and its various spectroscopic constituents. A. W.

1534. *Electric Analogue of Zeeman-effect.* **F. Paschen and W. Gerlach.** (Phys. Zeitschr. 15. pp. 489–490, May 15, 1914.)—Three different sets of experiments were made. In the first a mercury resonance lamp was so arranged that the luminescent mercury vapour was submitted to the action of an electric field in order to see whether the resonance radiation itself was subject to variation. This was analogous to the research of Malinowski, which gave his first curve [see Abstract No. 222 (1914)]. Secondly, the resonance radiation of this lamp was allowed to pass through a small absorption cell filled with mercury vapour at the room temperature, with the object of determining whether the absorption altered when the resonance lamp was submitted to the action of an electric field. This corresponded to Malinowski's second curve. Thirdly, the absorption vessel was provided with a condenser and experiments were made to see if the absorption of the light from the resonance lamp was altered by the action of an electric field on the absorbing vapour. Particulars of the apparatus are given. It was found that no appreciable variation of the absorption line could be detected, though the absorbing vapour was subject to fields ranging up to 14,500 volts/cm. Both the other researches, in which the vapour in the resonance lamp was acted on by the electric field, also gave negative results, no variation being observed. The intensity of the resonance radiation showed a variation of not more than 0·7 % in fields up to 12,000 volts/cm. It appears probable that there is no variation in this case, though wave-length variations in agreement with the results of Malinowski could be obtained when a magnetic field was used. [See also Abstract No. 1598 (1910).] A. W.

1535. *Mercury Green Line.* **J. C. McLennan and A. R. McLeod.** (Roy. Soc., Proc. Ser. A. 90 pp. 248–255, May 28, 1914.)—Describes measurements of the structure of the mercury line λ5461 as resolved by glass and quartz Lummer plates, and also of the Zeeman constituents of the line. It is shown that the formula $\Delta\lambda = \Delta\lambda_m(a_{s_1}^2 - a_m^2)/(a_{m_1}^2 - a_m^2)$ is the one which should be used in measuring up the fringe pattern produced by Lummer plates for determining small changes in wave-length; a_m being the distance of a main line fringe from the central line of the pattern, a_{m_1} that of the main line fringe of the next higher order, and a, being the distance from the central line of a satellite fringe of the same order as a_m. $\Delta\lambda_m$ represents that change in the wave-length of the light which would cause the fringe of the *m*th order of the system of fringes due to light of wave-length $\lambda + \Delta\lambda_m$ to coincide with the fringe of the $(m + 1)$th order of the system formed by the light of wave-length λ. This formula has been applied to the determination of the positions of the satellites of the mercury line λ5461 relative to the main component, when the line was resolved by a Lummer plate made of crystal quartz and also by two others made of glass. The results obtained with the quartz plate agree with the values recently found by Nagaoka and Takamine, who used a glass Lummer plate crossed with an echelon grating, while those obtained with the glass Lummer plates agree best with determinations previously made by McLennan with an echelon grating. Considerations are suggested in favour of the view that the green line consists of a series of lines closing together towards the centre, their position being regulated by some law which in the outer components simplifies approximately to a geometric progression. Evidence is also adduced in support of the view that a somewhat similar law applies approximately to the mercury arc line λ3341. A method of coincidence was used to illustrate the magnetic resolution of the line λ5461, and a value of $1{\cdot}82 \times 10^7$ was obtained for e/m. [See also Abstracts Nos. 1395 (1906), 494 (1912), 424 (1913).] A. W.

1536. *Magneto-Optics of Iodine Vapour.* **R. W. Wood and G. Ribaud.** (Phil. Mag. 27. pp. 1009–1018, June, 1914. Journ. de Physique, 4. Ser. 5. pp. 378–387, May, 1914.)—The magnetic rotatory polarisation of iodine vapour has previously been described [Abstract No. 2032 (1906)]. The aim of the present investigation was to determine the exact nature of the rotation produced by the lines of absorption, since more recent observations have shown that the earlier results dealt with rotations produced by close groups of lines, no record having been obtained of the nature of the rotation to the right and left of a single line. It was of especial importance to determine whether the rotation to the right and left of an absorption line was of the same nature, *i.e.* either positive or negative, as is the case with the D-lines of sodium, or whether any case of anomalous rotation occurred—that is, positive on one side of the line and negative on the other. The absorption lines investigated are numbered 2, 3, 4, 4′, 5, and 6, in accordance with the numbers used in previous papers on resonance spectra, these lines being covered by the broadened green line of the mercury arc. In this group of lines the direction of the rotation changes from line to line, which explains perfectly why the angular magnitude of the rotation is so small in comparison with that exhibited by the D-lines. The positive rotation due to a given line is nearly neutralised by the negative rotations of its two neighbours. It is also easy to see why the rotation on one side of a line may be much greater than on the other. Experiments were undertaken to see whether any evidence of a longitudinal Zeeman-effect could be observed, but no positive results were obtained. If the Zeeman-effect exists, it is less than 0·01 Å unit for a field of 20,000 gauss. Cotton has shown that if a sodium flame is placed in a magnetic field, between crossed nicols, the light traversing it in a direction perpendicular to the lines of force is re-established in the vicinity of the D-lines, if the planes of the nicols are at 45° with the lines of force. Using the same iodine bulb as in the earlier experiments the authors have obtained a marked restitution of light, too feeble, however, to permit of its examination with an echelon. With the crater of the carbon arc as a source the restored light was quite brilliant, and of the same emerald-green colour as in the longitudinal experiment. Steubing has observed a diminution of the intensity of iodine vapour fluorescence in a magnetic field amounting to as much as 80 %. Using a much more powerful field the authors have succeeded in almost completely abolishing the fluorescence. The effect of the field in reducing the intensity of the fluorescence becomes more marked as the vapour-pressure of the iodine is diminished. No explanation of the effect has up to the present been obtained. The magnetic rotations of the plane of polarisation in the vicinity of absorption bands may be divided into two classes: (1) Anomalous rotations, in which the sign changes in crossing the band, as observed by Cotton for certain solutions and by Wood for a solid film of a neodymium salt. Rotations of this nature appear to obtain in cases in which there is no change in the position of the band of absorption, but merely an alteration in velocities of right- and left-handed circular vibrations. (2) Rotations in which the sign is the same on opposite sides of the absorption band, as at the D-lines of sodium and the iodine lines. Rotations of this type are explained by the division of the line into a Zeeman doublet by the magnetic field. It seems probable, therefore, that there is a small Zeeman-effect for iodine, but it is doubtful if it can ever be detected, as it is of the order of magnitude of the width of the lines, probably much less in fact. The study of the magnetic rotation of the vapour of sodium by the improved methods given in the present paper will undoubtedly give much more satisfactory results, as the rotatory power of this vapour in the red and orange is certainly ten times as great as that of iodine. A. W.

1537. *Effect of Magnetisation on the Opacity of Iron to Röntgen Rays.* **A. H. Forman.** (Phys. Rev. 3. Ser. 2. pp. 306–313, April, 1914.)—The method adopted to investigate this subject proved very sensitive, and was capable of detecting a change in the opacity of one part in 10,000 under the most favourable conditions. Tests, in which the iron was magnetised in a plane perpendicular to the Röntgen rays, with its direction of magnetisation parallel to the axis of the X-ray tube, and also with its direction of magnetisation perpendicular to this axis, gave negative results. The method is now being extended to investigate the effect of applying a magnetic field parallel to the Röntgen rays and perpendicular to the plane of the iron. The high degree of sensibility obtained suggests that the method might be useful in other fields of research where the changes sought for are likely to be quite small. E. A. O.

1538. *Spectra of Secondary X-Rays.* **M. de Broglie.** (Nature, 93. p. 349, June 4, 1914.)—Hitherto X-ray spectra have been obtained by using the substances, whose spectra are required, as antikathodes inside a discharge tube. The author points out that the same end may be achieved by simply allowing a beam of X-rays from an ordinary bulb to fall on the substance whose spectrum is required, and afterwards examining the secondary rays emitted by it. Photographs of the spectra of zinc, copper, mercury (amalgam of zinc) were taken in this way without any trouble. Zinc amalgam showed five rays: two due to Zn, two due to Hg, and one due to some impurity (probably Fe). An experiment conducted with the substance contained in a thin paper bag was very striking. Using zinc oxide inside the bag, the presence of zinc was immediately made manifest. The author observes that the method promises to be particularly useful for experiments in which the rays to be examined are emitted under various conditions. E. A. O.

1539. *Intensity of Interference Spots with Zincblende and the Zincblende Space-grating.* **P. P. Ewald.** (Ann. d. Physik, 44. No. 2. pp. 257–282, May 12, 1914.)—The object of the paper is to test the correctness of the Bragg models for a variety of crystals by showing that the transmission photographs can be predicted from such models. Sommerfeld treated of the diagrams with three-fold and four-fold axes (Solway Congress, Brussels, 1913). The present paper deals also with the two-fold axis diagram and oblique transmission. As basis for the verification are taken the following facts. (1) The incident beam consists of a continuous spectrum, for otherwise a slight tilt would cause the pattern to alter completely. (2) There is a lower limit to the value of λ/a (where $a =$ grating constant) for otherwise the whole plate would be blackened. (3) There is also an upper limit to the wave-length, though this does not reach as high as $\lambda = a$. It is shown that all the spots to be expected from the postulated crystal structure in view of these restrictions in wave-length actually appear. The intensities of the spots are connected together in a regular manner, for they can be shown to be in accordance with a distribution in the primary beam, represented by a smooth curve. Since the strong part of this curve embraces only about one octave, it is only necessary to insert the intensity of an interference spot in the curve in order to determine the wave-length giving rise to the spot. Absolute numerical correspondence is vitiated by the influence among other things of absorption and heat motion. The zincblende crystal structure is considered in detail. From Bragg's reflection data the structure appeared to be a face-centred cube of zinc atoms with the sulphur atoms disposed in an exactly similar configuration, and removed from the zinc atoms one-quarter of the way along the diagonals of the zinc cubes. Thus, if the side of a cube be represented by $4 (a = 4)$, the zinc atoms are completely represented by

$$\begin{array}{lll} X \equiv 0 & Y \equiv 0 & Z \equiv 0 \\ X \equiv 2 & Y \equiv 2 & Z \equiv 0 \\ X \equiv 2 & Y \equiv 0 & Z \equiv 2 \\ X \equiv 0 & Y \equiv 2 & Z \equiv 2 \end{array}$$

while the sulphur atoms are completely represented by the co-ordinates resulting on adding 1 to each of the above co-ordinates. The intensity of any interference ray resulting from a face-centred cube is easily shown to be proportional to

$$(1 + e^{i\pi/2(2h_1 + 2h_2)} + e^{i\pi/2(2h_1 + 2h_3)} + e^{i\pi/2(2h_2 + 2h_3)}),$$

where h_1, h_2 and h_3 are the orders of interference in the three principal directions in the crystal. This factor can only be equal to 4 or 0, the latter occurring when the three indices are partly even and partly odd. The sulphur atoms being also arranged in face-centred cubes give the same interference pattern, but not necessarily the same intensity. The above factor has therefore to be multiplied by $(1 + Ae^{i\pi/2(h_1 + h_2 + h_3)})$. If A is equal to unity, the latter factor becomes zero for $h_1 + h_2 + h_3 = 4n + 2$. This case is realised in the diamond. Since in zincblende $A < 1$ a considerable diminution in intensity in these spots takes place instead of complete obliteration. The complete systems of interference points for the diagrams with four-fold, with three-fold and with two-fold axes are enumerated, using as "enumerating-index" h_3, $s(= h_1 + h_2 + h_3)$ and $\sigma(= h_2 + h_3)$ in the three cases respectively. In making this enumeration, limits are set to the values of $2a/\lambda$ (between 16 and 60), of $s(= h_1^2 + h_2^2 + h_3^2 < 100)$ and of ϕ (angle between incident beam and interference ray$<\pi/4$). Against each point so found is placed the intensity actually found in the photographic records of Friedrich and Knipping, and finally the intensity is plotted against wave-length as calculated in the above enumeration. In every case the intensity is found to lie on the same smooth curve, although the absolute ordinates of the curve may depend on the "enumeration-index." This curve thus constitutes an analysis of the incident beam showing a maximum at $2a/\lambda = 32$. A few points lie completely away from the curves, the ordinates being far too small. These prove to be those mentioned above where $h_1 + h_2 + h_3 = 4n + 2$, thus affording striking confirmation of Bragg's model for zincblende. The lack of correspondence between the curves and the true distribution of energy in the primary X-ray spectrum depends upon the relative preponderance of the absorption factor, the index-factor (Debye-Lorentz), and the heat-motion factor. In the oblique transmission photograph not only are the positions of the spots altered, but the wave-lengths corresponding to them are also changed. Knowing the intensity distribution in the primary beam we should be able to predict the relative intensity of the various spots in the two photographs. This practical test shows complete agreement with theory. The crystallographic properties of the Bragg models for zincblende and diamond are also shown to be in accordance with reality. E. A. O.

1540. *New Diffraction Photographs.* **M. E. Hufford.** (Phys. Rev. 3. Ser. 2. pp. 241–243, April, 1914.)—If monochromatic light from a point source is made to pass through a circular opening and fall upon a screen, and if the size of the opening is chosen so that the difference in optical paths by way of the boundary and by way of the centre of the opening is some whole number of half wave-lengths of the light used, then in the illuminated area where the paths end, there will be interference. This is verified by photographs of the diffraction patterns obtained from a series of openings varying consecutively from 1 to 25 half-period elements in size, the light chosen being the intense fluting, beginning at wave-length 3880×10^{-8} cm. in the spectrum of the carbon arc. The second portion of the paper deals with the properties of the Arago white spot at the centre of the geometric shadow of a large disc or sphere. The very large bright spots obtained showed that each point in the aperture produces a corresponding effect in the shadow, which suggests that the aperture may be any sort of figure, and in the shadow of the disc or sphere there should be an inverted image of it. The result of experiment proved this to be the case. From the plates given in the paper it is seen that, with sufficient contrast on a photographic transparency, the transparency may be actually reproduced by using an opaque disc or sphere in place of a lens. The definition of the diffraction pattern thus obtained is surprisingly good. E. A. O.

1541. *X-Rays and Crystalline Structure.* **W. H. Bragg.** (Engineering, 97. pp. 814–815, June 12, 1914. Discourse delivered at the Royal Inst.)—A general summary of recent results in this branch of investigation.

1542. *Ionisation of Water-vapour by α-Particles.* **B. Bianu.** (Le Radium, 2. pp. 65–69, March, 1914.)—The experiments deal with a determination of the ranges of the α-particles of polonium in saturated water-vapour at temperatures between 75° and 100° C. The product $a \times d$ was found to be constant and equal to 0·00375, where a is the range and d the density in gm./cm.^{3}

From the total areas of the Bragg ionisation curves it was found that the total ionisation in water-vapour is practically equal to that in air—as might have been predicted from considerations of chemical composition—and, further, the range was in accordance with Bragg and Kleeman's square-root law. Anomalous results were, however, obtained in experiments on ionisation by collision in water-vapour. **E. M.**

1543. *Wave-length of the Soft γ-Rays from Radium B.* **E. Rutherford** and **E. N. da C. Andrade.** (Phil. Mag. 27. pp. 854–868, May, 1914.)—The γ-rays from a thin-walled α-ray tube, filled with a large quantity of radium emanation, were allowed to fall at a definite angle on a crystal, generally rocksalt, and the intensities of the "reflected," or rather, diffracted, rays were examined by a photographic method. Difficulties were encountered owing to (1) the long exposure necessary; (2) the direct action of the penetrating γ-rays from RaC which had to be screened by thick pieces of lead, and (3) the effect of the primary and secondary β-rays. The effects of the latter were reduced by placing the source and crystal in a magnetic field of 2500 gauss. In the present experiments only the soft rays, known to come from RaB have been investigated, since these were found to be reflected at convenient angles. The results are shown in the following table.

RADIUM B. Soft γ-ray Spectrum.			PLATINUM. X-ray Spectrum.
Angle of reflection from Rocksalt.	Wave-length (in cm.).	Intensity.	$\frac{\text{Angle of reflection}}{1{\cdot}122}$
8° 6′	0·793 × 10⁻⁸	m.	
8° 16′	0·809	m.	
8° 34′	0·838	m.	8° 27′
8° 43′	0·853	m.	8° 43′
9° 23′	0·917	f.	
9° 45′	0·953	m.	
10° 3′	0·982	s.	10° 2′
10° 18′	1·006	m.	10° 13′
10° 32′	1·029	m.	
10° 48′	1·055	f.	
11° 0′	1·074	f.	
11° 17′	1·100	f.	
11° 42′	1·141	m.	
12° 3′	1·175	s.	12° 3′
12° 16′	1·196	m.	
12° 31′	1·219	f.	
13° 0′	1·266	f.	
13° 14′	1·286	f.	
13° 31′	1·315	f.	
13° 52′	1·349	m.	
14° 2′	1·365	m.	

It will be seen that the γ-ray spectrum is of the same general type as that found by Moseley, etc., when platinum is bombarded by kathode rays (Column IV).

Recent work has shown that RaB is identical in chemical properties with Pb, and on the nucleus theory of an atom this is explained by assuming that the central charges are the same. On this idea RaB ought to give an X- or γ-ray spectrum almost identical with that of lead. From Moseley's results lead ought to have a central charge of $82e$ [Abstract No. 1249 (1914)], and ought to give the main line in the X-ray spectrum reflected by rocksalt at an angle of 12·07°. The strongest line of RaB was found to be reflected at 12·05°—a very close agreement. In further experiments the γ-ray spectra of RaB and lead were compared under as nearly as possible identical conditions. The spectrum in the latter case was obtained by exciting γ-rays in a thin strip of lead by allowing a strong pencil of β-rays to fall on it. Owing to experimental difficulties only two lines of lead could be measured. These gave angles of reflection of 10° 2′ and 12° 0′ in good agreement with the strong lines of the RaB spectrum.

The bearing of these results on the structure of the atom is discussed.

E. M.

1544. *β- and γ-Rays and the Structure of the Atom.* **A. van den Broek.** (Nature, 93. pp. 376–377, June 11, 1914.)—The paper deals with empirical and theoretical considerations of the values given by Rutherford and Robinson [Abstract No. 251 (1914)] of the velocities of the pencils of β-particles emitted from RaB, and also of the wave-lengths of the γ-rays of RaB given by Rutherford and Andrade [see preceding Abstract]. It is found that the frequencies of the γ-rays are nearly proportional to the squares of the integers between P [periodic number = 60, as determined in Abstract No. 569 (1914)] and A/2 (half the atomic weight, 107), and that the β-ray spectrum contains only velocities proportional also to integers between P and A/2. The author concludes from this that the radii of the inner electrons are all different, thus forming a "planetary" rather than a "saturnian" atom [*cf.* Nicholson, Abstract No. 1246 (1914)]. Thus different elements ought to have partly identical β- and γ-rays and the so-called β-ray spectra might consist of electrons expelled by the β-particles and not of the β-particles themselves. The author further suggests an alteration of Moseley's formula [Abstract No. 1249 (1914)] based on the above idea.

E. M.

1545. *The Origin of Actinium.* **O. Göhring.** (Phys. Zeitschr. 15. pp. 642–645, June 15, 1914.)—It is now generally accepted that actinium is a relatively short-lived element with a half-time value of the order of magnitude 100 years, and that it cannot therefore be a primary radio-active element, but must have a long-lived parent substance. It seems also certain that there must be a genetic connection between the Act series and the Ur-Ra series. The present experiments have been made in an unsuccessful attempt to separate the parent of actinium. A. E. G.

1546. *Uranium Y.* **O. Hahn** and **L. Meitner.** (Phys. Zeitschr. 15. pp. 236–240, March 1, 1914.)—The authors study the substance found associated with UrX when prepared by the iron method. This was called Uranium Y by Antonoff [Abstract No. 1684 (1911)]. They confirm its existence, although it has the same chemical properties as UrX, by its half-period of 25·5 hours and its emission of slow β-rays. UrY is produced either by Ur_1 besides UrX, or by Ur_2 besides ionium. E. E. F.

1547. *Radio-activity of Springs near Williamstown, Massachusetts.* **J. E. Shrader.** (Phys. Rev. 3. Ser. 2. pp. 339–345, May, 1914.)—A warm spring near Williamstown has been found to contain radium. The paper describes apparatus used for determining the radio-activity of the water, and a number of results of tests made on other springs are given. H. H. H.

HEAT.

1548. *Van der Waals' Equation and Nernst's Theorem.* **L. Schames.** (Deutsch. Phys. Gesell., Verh. 16. 11. pp. 518–528, June 15, 1914.)—A theoretical treatment based on the researches of various investigators. It appears (1) that for diatomic and triatomic gases (perhaps also for monatomic gases) the value of the specific heat at the critical temperature is just twice that at absolute zero. (2) In place of the gas constant in van der Waals' equation the integral value of $C_p - C_v$ should be substituted. (3) Nernst's theorem is extended; for condensed systems when $T = 0$ and $p = 0$ the energy is independent of the state of aggregation or of its modification. This leads to the adoption of two other critical points: (i) solid-undercooled fluid, where $p = 0$, $T = 0$; and (ii) solid-fluid where $p = \infty$, $T = T_k$, T_k being the temperature of the ordinary critical point. (4) It appears that for water the energy contents at the points named above have simple ratios to each other. At all events, for the ordinary critical point, U being the thermodynamic energy, $U_k = U_o$. (5) Nernst's theorem is part of a more general one, that at the critical points the differential coefficients of the quantities defining the physical state attain extreme values. A. W.

1549. *Radiation and the Quantum Theory.* **J. H. Jeans.** (Physical Soc. Publication, [90 pp.] London, 1914.)—This is a general report on the present state of the problem, dealing in seven chapters with: The need for a quantum theory: The radiation problem on the basis of Newtonian mechanics: Development of the quantum theory: Line spectra: Photoelectric effect: Specific heat of solids: Physical basis for the quantum theory. Something in the nature of the quantum theory is imperatively demanded by the observed facts of full radiation unless the possibility of thermodynamic equilibrium between matter and ether, or alternatively, the very existence of the ether, be denied. The latter alternative, with its consequent repudiation of a constant speed of radiation through the ether, leads, as the relativity controversy has shown, to the subversion of our fundamental concepts of space and time. In the radiation problem the Newtonian mechanics suffice so long as $h\gamma/RT$ is small, *i.e.* so long as the average energy RT of a vibration contains many quanta. Moreover, the quantum theory supplies explanations in other phenomena where only one or a few quanta are concerned, *e.g.* The line spectra of hydrogen, helium, and perhaps lithium (Bohr's theory): Photoelectric phenomena, including the infra-red band apparently characteristic of all substances: The decrease of atomic heat to vanishing-point at the absolute zero temperature (Debye's theory), and the identity of the temperature-atomic heat curves, for all substances (except for differences of temperature scale). In all these cases the Newtonian mechanics fail. The quantum theory, however, appears from Poincaré's investigation [Abstract No. 841 (1912)] definitely to involve some kind of atomicity either of energy or of action (energy × time), and this seems to be absolutely irreconcilable with the undulatory theory of light, and presents other considerable, if less formidable, difficulties. At present there is no solution of these difficulties in sight, but the author points out that no physical explanation has yet been found for the atomicity of *e*, and suggests that a greater knowledge of the nature of the equations of the ether may possibly show that they contain the quantity e, and possibly that this is the same thing as saying that they contain the quantity h. It might then appear that the Newtonian mechanics represent an approximation holding good for the larger scale phenomena, where they have hitherto been found reliable, but are not applicable to the small-scale phenomena in which electrons and light-waves are directly involved.

G. W. DE T.

1550. *Thermodynamics of Radiation.* **H. L. Callendar.** (Phil. Mag. 27. pp. 870–880, May, 1914.)—In his previous communication [Abstract No. 286 (1914)] the author's proposed formula for full radiation was derived from a quasi-molecular theory of radiation with free use of the close analogy between full radiation and an ideal vapour. An alternative method is here given starting from the generally accepted fundamental facts: (1) The condition within a vacuous enclosure at constant temperature T is representable by an isotropic energy stream Q per sec. per sq. cm., which is a function of T only. (2) This will hold for each separate frequency γ, giving partial energy streams q, which are functions of T and γ only. (4) The full and partial energy densities per cm.^{3} at any moment will be $4Q/c$ and $4q/c$, respectively, where c is the velocity of light. (5) As a perfectly reflecting sphere filled with homogeneous and isotropic radiation of different frequencies expands with a speed small as compared with c, the wave-length of every component will increase proportionally to the radius (Doppler-effect). (6) In adiabatic compression the whole energy of each component which retains its identity will vary as its frequency. This is the simplest assumption for the variation of energy and agrees with electromagnetic theory, and it follows that the whole energy varies as $1/r$, so that $r^4 q d\gamma$ is constant. (7) The radiation pressure $p dv$ due to the stream $q d\gamma$ is deducible by equating the work in a small expansion dr to the energy loss of the stream, giving $p = 4q/3c$, and for the whole radiation, $P = 4Q/3c$, the pressure and the work resulting essentially from change of frequency due to Doppler-effect. (8) Full radiation remains such in adiabatic change, and so by Carnot's principle T varies as the frequency of each component, and therefore as $1/r$. The energy density of the pressure then varies as T^4 for the radiation as a whole and for each component (Stefan-Boltzmann law), and λT, or γ/T, is constant for each component (Wien's law). Both laws are summed up in Wien's expression $q = C\gamma^3 F(\gamma/T) = CT^3 f(\gamma/T)$, where F and f are undetermined functions expressing the distribution in full radiation.

Now each frequency seems to travel without change in free space, so that Carnot's principle should apply to each energy stream q, and its latent heat of isothermal emission should therefore be $T(dp/dT)_\gamma$, which is not proportional to q as is generally assumed. This conclusion is shown to follow from the Doppler-effect in adiabatic expansion, instead of being in conflict with it. The entropy will then be $(dp/dT)_\gamma$, and the intrinsic energy (E/v in previous paper) is $T(dp/dT)_\gamma - p$, and then, from Wien's law, E/pv must be a function of (ν/T), depending on the distribution. Its form was assumed to be $b\nu/T$, on the ground that intrinsic energy varies as frequency. This leads to the simplest relations; has been shown to agree in fundamentals with atomic theory; and is here shown by the author to agree satisfactorily with experiments.

G. W. DE T.

1551. *Radiation and the Quantum Theory.* **J. Duclaux.** (Comptes Rendus, 158. pp. 1879–1882, June 22, 1914.)—The author argues, on the basis of his identification of Planck's quantum with a definite "element of energy" involved in the formation or rupture of an atomic bond [Abstract No. 888 (1913)], that transference of energy between ether and matter may take place continuously whenever there is no such rupture, *e.g.* in monochromatic radiation and in the absorption of light by cold bodies. The identification would enable our extensive knowledge of chemical phenomena to be used for the interpretation of the radiation phenomena, of which we are comparatively ignorant. G. W. DE T.

1552. *Gas Theory.* **A. Rosenthal.** (Ann. d. Physik, 43. No. 6. pp. 894–904, March 20, 1914.)—Investigates the utility of P. and T. Ehrenfest's "quasi-ergode" hypothesis (Enzykl. d. Math. Wiss. 5, 2 (32) No. 10A), which may be expressed as follows: Every gas is a quasi-ergodic system, *i.e.* a single undisturbed motion of the system, if continued indefinitely, approaches indefinitely (not "passes through," as originally postulated in the original ergode hypothesis) every physically possible point of the energy surface of the total gaseous energy. The author shows that the gas theory may be built up in a simple manner upon this hypothesis. E. E. F.

1553. *New Relation between the Critical Quantities: Unity of all Substances in their Thermal Behaviour.* **J. J. van Laar.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 924–938, April 23; and pp. 1047–1064, May 29, 1914.)—The author discusses, with various examples, means of determining the shape of the function, $b=f(v)$ [see Abstract No. 1284 (1914)], various complicated expressions being derived which fulfil all the necessary conditions. T. H. P.

1554. *Vapour Pressure Lines of the System Phosphorus.* I. **A. Smits, S. C. Bokhorst,** and **J. W. Terwen.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 1174–1186, May 29, 1914.)

1555. *Character of Luminous Metal Vapours in Flames.* **H. Kohn.** (Ann. d. Physik, 44. No. 5. pp. 749–782, June 19, 1914. Extract from Dissertation, Breslau.)—The author has made experiments with the view of ascertaining if the light emitted by luminous metallic vapours in a Bunsen flame follows Kirchoff's law and hence consists of temperature rays. The current passing through a Nernst lamp, the image of which falls on the luminous flame, was adjusted until the spectrum of the flame on the continuous spectrum of the Nernst lamp just disappeared. The flame will then be a temperature radiator if the dark temperature of the flame coincides with the temperature of the Nernst lamp. The temperature of a Pt-Rh wire hung in the flame was measured pyrometrically and was found to be lower than that of the Nernst lamp. This is due to the fact that the wire is cooler than the surrounding flame in consequence of its greater radiation. When the wire is heated electrically until its temperature coincides with that of the Nernst lamp, it is found that this temperature is also that of the flame within ± 10°. It is therefore demonstrated that metallic vapours are temperature radiators and that the emission of light does not depend on luminescence. This is the case both with the hot flames of illuminating gas and also with these flames cooled to about 1250° by introduction of CO_2. On the other hand, with the cold flames obtained by burning suitable mixtures of carbon disulphide and air, luminescence seems to occur at about 670°. T. H. P.

1556. *New Method of Using the Féry Radiation Pyrometer.* **G. Millochau.** (Comptes Rendus, 159. pp. 171–174, July 13, 1914.)—The author shows how the Féry radiation pyrometer by means of readings made with and without an absorbing screen can be used for the determination of temperatures when the image produced by the telescope is smaller than the disc of the instrument. Readings made in this way agree to within 20° with readings made with the whole of the disc illuminated. F. J. H.

1557. *Electrical Ignition of Gaseous Mixtures.* **W. M. Thornton.** (Roy. Soc., Proc. Ser. A. 90. pp. 272–297, May 28, 1914.)—The author has studied the ignition of mixtures of air with various gases and vapours by means of direct- and alternating-current break sparks between iron and, in some cases, nickel poles.

Direct Current.—The higher the voltage, the less the current required for ignition; the curves obtained closely resemble the characteristics of steady arcs, which are known to be maintained by ionised vapour between the poles, and they have the same form at all percentages between the inflammable limits. With the paraffins, methane, ethane, propane, butane, and pentane, the change of susceptibility to ignition varies with the percentage of gas in the same manner in all cases. Each curve has three distinct portions, that which gives the peculiar form being a straight line passing through or nearly through zero and indicating that over the greater part of the range of inflammability the least igniting current is very closely proportional to the absolute number of molecules of combustible gas in unit volume of the mixture. At the lower limit is a steep branch showing that the transition from the most inflammable mixture to that which cannot be ignited is sudden. The upper limit is approached rather more gradually. The curves also indicate: (1) That the same igniting current, that is, the same energy, is required for each most inflammable mixture, in spite of the great difference between the calorific values of methane and pentane; (2) that there is no square law, except at the limiting mixtures, and (3) that the most inflammable mixture is not always that in the proportions required for perfect combustion, but sometimes contains air in excess. It is clear that combustion is an important factor even in the initial stage, yet there is evidence that the influence of the discharge from the spark, whatever its nature, acts directly upon the atoms in a molecule rather than upon the molecules as a whole.

Measurements made with the simple alcohols show that the slope, I/p—where I represents the igniting current and p the percentage of combustible gas present—of the base of the curve is slightly decreased by the addition of the oxygen atom to the paraffin molecule, so that the inflammability of the vapour measured by this slope is lower. Further, with both iron and nickel poles, the alcohol of greater molecular weight requires the greater current for ignition. Here, too, the ratio $I:p$ is proportional to the number of atoms, n_{C+H}, of combustible gas in the molecule more nearly than to the calorific value. The curve for benzene has no straight part, and is nearly symmetrical within the limits of combustibility. The most sensitive mixture contains about 4·8 % of benzene, combustion to CO requiring 4·47 %. The same form and position of the curve are found with alternating as with continuous current. The evidence is therefore strong that in so far as the magnitude of the igniting current is an indication of the atomic charges occurring at the instant of explosion, CO is the chief and first product of combustion, the formation of CO_2 being a much slower process than with lighter gases. The after-burning of benzene may account for the fact that benzole fuel gives less shock than petrol, the combustion being less sudden and extended more over the stroke. With carbon disulphide, the igniting current is extremely small, viz. 0·82 amp., and the mixture giving complete combustion is nearly the most inflammable one. The glass discharge tube from the explosion vessel becomes rapidly coated with sulphur after the ignition, a high state of atomic dissociation of the combining gas during the explosion being thus indicated. Carbon disulphide being an endothermic compound, the supply of heat to it by the combustion of a small portion of the mixture or from the arc may cause the rest to explode with liberation of free carbon and sulphur. The explosion is violent with all mixtures. With hydrogen the ignition current is the same for all mixtures except towards the limits of inflammability, so that the ignition is an isolated molecular process, independent of concentration and requiring only a certain intensity of molecular movement for its production. The CO curve differs slightly from the hydrogen curve, and these two show, as it were, the genesis of the straight-line type from a parabola symmetrical between the limits of inflammability. Increase of the circuit voltage has no influence on the position of the point of greatest inflammability, but is accompanied by regular and rapid diminution of the slope of the curve. At voltages over 100, the igniting current is nearly the same over the whole range of inflammability, this being an important point in the working of internal combustion engines. The period known as the time of explosion appears to be capable of a simple mechanical explanation, the square law followed by petrol indicating that the "explosive unit" is there large compared with the mass of inert gas, while the higher limits of inflammability of simple gases are due to the smaller volume and mass of the explosive unit.

Alternating Current.—The differences between the results obtained with continuous and alternating currents arise from the dragging of the electrons or ions across the spark from pole to pole and the prevention of their escape into the gas. Alternating igniting currents have therefore to be much greater than continuous currents at the same voltage. This difference is increased by the approach of the period of the current to the time of duration of the break-spark. The latter varies with the voltage so that the igniting current remains constant over a wide range of voltage. The igniting currents of the paraffins increase as the order rises, the product of the minimum current for each gas and the percentage at which it occurs being constant. The product of the number of atoms in a molecule of combustible gas and of the above percentage is also constant, so that the number of atoms in unit volume in all the most inflammable mixtures is the same. The igniting current is most nearly proportional to the number of atoms in the group of one molecule of combustible gas and the oxygen required for combustion, forming an explosive unit. The paraffin gases after methane are most easily ignited at a percentage giving combustion midway between CO and CO_2, and both limits of inflammability are symmetrical from this point. Benzene is most easily ignited when burning to CO, alcohol to CO_2. Carbon disulphide and hydrogen have the forced or continuous-current type of ignition. External ionisation which does not itself cause ignition has no measurable influence on the least igniting currents by break-sparks.

From the great differences in magnitude and type between continuous- and alternating-current ignition, it seems probable that ionisation of some kind precedes combustion. That a gas has a particular temperature of inflammation may mean that ionisation by collision begins at this temperature, with absorption of energy from the source, or, later, from that liberated by recombining atoms. Thus, when the molecular energy set free by combustion of a molecule exceeded that required for initial ionisation of an adjoining molecule there would be true explosion, and since it is probable that all three modes of molecular motion, translation, rotation, and vibration, take part in the process of ionisation by collision, the influence of temperature, depending only on the translational energy may be in certain cases of secondary importance. T. H. P.

1558. *Heat Conductivity and Viscosity of Monatomic Fluids.* **L. Brillouin.** (Comptes Rendus, 159. pp. 27–30, July 6, 1914.)—Following theory given previously by Debye and by M. Brillouin [see Abstract No. 446 (1913)], a formula is developed for the heat conductivity of a fluid. From this formula it appears that the conductivity becomes very great at very low temperatures. Formulæ are also obtained for the coefficient of viscosity of deformation and of viscosity of compression of a fluid, which of course are the same for gases.

A. W.

1559. *Ratio of Specific Heats of Chlorine.* **J. R. Partington.** (Phys. Zeitschr. 15. pp. 601–605, June 15, 1914.)—Measurements are made of the velocity of sound in chlorine by the modified Kundt tube method as used by Behn and Geiger [see Abstract No. 249 (1908)]. This gives the "ideal ratio of specific heats" from which by formulæ already deduced by the author from the Berthelot characteristic equation [Abstract No. 691 (1914)] the true values of the molecular heats and their ratio are deduced. The values obtained are $C_p = 8{\cdot}49$ cals., $C_v = 6{\cdot}39$ cals., and $C_p/C_v = 1{\cdot}329 \pm 0{\cdot}001$.

F. J. H.

1560. *Specific Heat of Metallic Alloys consisting of Solid Solutions.* **L. Rolla.** (Accad. Lincei, Atti, 23. pp. 616–621, April 19, 1914.)—It has been shown by Koref [Abstract No. 948 (1912)] that Lindemann's formula gives the specific heats of compounds if the corrected vibration frequencies corresponding with the melting-points are inserted. The author has investigated the melting-point diagrams of a number of alloys of Ag-Au, Cu-Au, Cu-Ni, Ni-Mn, and Cu-Mn, and has calculated their specific heats by the above formula. The values thus obtained are compared with those measured directly by means of Koref's copper block calorimeter (− 190° to 0°) or Schottky's toluene calorimeter (0° to 25°). The agreement between the two sets of numbers is only moderately good, but gives a qualitative indication of the existence of curves of atomic frequency. T. H. P.

1561. *Specific Heat of Helium.* **A. Eggert.** (Ann. d. Physik, 44. No. 4. pp. 643–656, June 4, 1914. Extract of Inaug. Dissertation, Marburg, 1910.)—The specific heat of helium at constant pressure is determined at − 15°, + 50°, + 100°, and + 150° C. by the Regnault method; the mean value between − 15° and + 150° being given as $C_p = 1{\cdot}2662 \pm 0{\cdot}0011$. The object of the investigation was to test the atomicity of He from the formulæ $M \,.\, C_v = M \,.\, C_p - 2{\cdot}004$ and $A \,.\, C_v = 3{\cdot}006$ given by Richarz, where M and A are the molecular and atomic weights, and C_p and C_v the specific heats of the gas at constant pressure and constant volume respectively. Helium is shown to be monatomic and the value of the ratio of the two specific heats as calculated from the measured value of C_p and the above value of $A \,.\, C_v$ shows good agreement with well-known direct measurements. The observations agree fairly well with those of Scheel and Heuse [Abstract No. 827 (1913)], but show no variation with temperature within the limits of experimental error.

F. J. H.

1562. *Leonard Weber's Photometer as an Optical Pyrometer.* **A. Replewa.** (Russian Physico-Chemical Soc., Journ. 45. 7. pp. 862–870, 1913.)—The use of the Weber photometer for the measurement of high temperatures is based on the formula, $E = C_1 . \lambda^{-5} . e^{-C_2/\lambda T}$, expressing the relation between the light, E, emitted by an absolutely black body, its absolute temperature T and the wave-length λ, C_1 and C_2 being constants and e the base of the natural system of logarithms. It is shown that, if E_1 and E_2 are the values of E corresponding respectively with λ_1 and λ_2, $\log (E_2/E_1) = A - B/T$. Thus the relation between E_2/E_1 and $1/T$ is expressed graphically by a straight line. A magnitude proportional to E_2/E_1 may be measured by means of the Weber photometer. Thus, if the intensity of the emitted light passing through a red glass (E_{rd}) and through a green glass (E_g) be measured, $E_{rd} = C_{rd} . R^2/r_{rd}^2$ and $E_g = C_g . R^2/r_g^2$, where C_{rd} and C_g are constants for the given photometer, R is the distance, constant in both cases, of the source of heat from the screen, and r_{rd} and r_g are the distances of the screen from the lamp. From this it follows that, $r_{rd}^2/r_g^2 = KE_g/E_{rd}$ and $\log (KE_g/E_{rd}) = A_1 - B/T$, where $A_1 = A + \log K$. A_1 and B being known, measurement by the photometer of KE_g/E_{rd} gives T. In order to determine A_1 and B, the photometer was calibrated by means of a zirconium lamp, through which was passed a current, varied by a rheostat. T. H. P.

1563. *Actual and Black-body Temperatures.* **C. C. Bidwell.** (Phys. Rev. 3. Ser. 2. pp. 439–449, June, 1914.)—Comparisons are made between the actual and black-body temperatures of Fe, Au, Ag, Cu, and Ni, both solid and liquid, over the range 1000° to 2000° abs. Except in the case of iron which was heated in a crucible, the specimen was heated in a cavity cut in a carbon rod heated electrically, the surface of the metal protruding slightly beyond the carbon surface. The carefully calibrated Morse optical pyrometer, in which light as nearly as possible monochromatic of wave-length 0·66 μ was used, was directed towards the metal surface and towards a neighbouring air cavity in quick succession, the readings giving the black-body and the actual temperatures respectively. Independent readings of actual temperatures were also made by means of carbon-graphite thermo-couples [see Abstract No. 1602 (1914)], which confirmed the cavity measurements. By means of Wien's law the relative emissivities were calculated, the results being plotted against the actual temperatures. When the solid surface was obtained by freezing the molten metal, care being taken to avoid all traces of oxide, continuous curves were obtained for the passage from the solid to the liquid state. Solid surfaces prepared artificially always showed a sudden drop in emissivity on melting. The relative emissivities of Au, Cu, and Ag are very small and practically independent of temperature except at the highest temperatures where a slight increase with increasing temperatures was found. Solid iron has a fairly constant emissivity, but that of solid nickel decreases with increasing temperature, the coefficient being 0·000125. With both molten iron and molten nickel there is a rapid increase in emissivity with temperature; this the author attributes to the solution of carbon. The values of the relative emissivity agree well, except in the case of iron, with those of the coefficient of absorption at 25° C. found by Rubens and Hagen.
F. J. H.

SOUND.

1564. *Architectural Acoustics.* **F. R. Watson.** (University of Illinois, Bull. 11. No. 73. pp. 8–29, March 16, 1914.)—A general survey of present knowledge of this subject together with a special examination of the defective acoustics of the auditorium of the University of Illinois and its treatment.

The chief trouble in defective halls usually arises from reverberation and echoes. The former is the common defect and refers to the slow decadence of sound from the many reflections occurring at the hard smooth surfaces of its walls before the energy is dissipated. The obvious cure is to have rougher, more porous surfaces, *i.e.* covering the walls and floor with hangings and carpets. W. C. Sabine deduced from his experiments that t, the time of reverberation, was given by $t = 0{\cdot}164\text{V} \div a$...(1), where V is the volume of the room and a the absorbing power of the different materials present, the following being the chief values for a.

One Square Metre of Surface.	a.
Window space	1
Glass, plaster, or brick	0·025
Heavy rugs, curtains, etc.	0·25
Hair felt, 1 in. thick	0·75
Audience	0·96

W. S. Franklin theoretically obtained the formula $t = 0{\cdot}1625\text{V} \div a$...(2).

Distinct echoes may also occur in a hall, and these may be removed or rendered less objectionable by changing the angle of the walls which produce them or by covering these walls with absorbent materials. The author has not discovered a single case in which the installation of wires has resulted in any pronounced improvement. Reflecting or sounding boards may be used with advantage if specially arranged to suit the particular case. The heating and ventilating arrangements may also affect the acoustics of a hall, but usually the differences of temperature and of speeds are too small to have any marked influence.

The auditorium at Illinois was dome-shaped and had many subordinate curved surfaces which focused the sounds in an objectionable manner. After a complete exploration of its behaviour several remedies were applied. The mean time of reverberation determined from nearly 400 observations was 5·90 secs.; calculated by Sabine's formula (V = 11·800 cub. m.), this time came out as 6·4 secs.—a good agreement. Thick carpets were placed on the stage, heavy velour curtains 18 × 82 ft. hung on the wall at the rear of the stage, a large canvas painting (400 sq. ft.) was introduced, and the glass removed from the skylight in the ceiling. This reduced the time of reverberation of the hall when empty to 4·8 secs. With an audience present this value was reduced still more, and when the hall was crowded the reverberation was not troublesome. Pronounced echoes, however, still gave trouble. These were prevented by draperies hung in the dome.

As to the use of a sound-board, one was constructed of plaster in a para-

boloidal form and acted well for a single speaker, but some objected to its appearance; also it was useless for a chorus or band, so that it was discarded.
E. H. B.

1565. *Vibrations Proper to Coupled Systems.* **P. Debye** and **J. Kern.** (Phys. Zeitschr. 15. pp. 490–497, May 15, 1914.)—A mathematical paper whose chief points are as follows:—(1) For continuous systems M. Born established the theorem that the acoustic spectrum of a double system may be regarded as the superposition of the spectra of the separate single systems. (2) This theorem is then assumed valid for molecular systems which are coupled only by their surface conditions. (3) This assumption is then tested by working out the case of two coupled chains of quasi-elastic particles, the result being in satisfactory accordance with (2). (4) The introduction of individual frequencies for two coupled systems is in contradiction with (2). (5) The thermodynamic function is also applied to the problem. [See Abstract No. 918 (1914).]
E. H. B.

1566. *Sensitiveness of the Ear to Musical Sounds.* **Marage.** (Comptes Rendus, 158. pp. 1438–1440, May 18, 1914.)—The author has previously shown (1905), that for each vowel a certain minimum energy is necessary for audibility at a given pitch. It was then desirable to ascertain if a similar relation held good for certain musical sounds accompanied by a number of harmonics. For this a test was made by allowing a class of 300 students at the Sorbonne to hear compositions of the sixteenth and seventeenth centuries on various instruments of that epoch, harpsicord, clavicord, lute, and viol. About half of these auditors gave a good account of what they had heard and the results show distinct sensitiveness to certain musical sounds. E. H. B.

1567. *Æolian Tones.* **F. Krüger** and **A. Lauth.** (Ann. d. Physik. 44. No. 5. pp. 801–812, June 19, 1914.)—Discusses the theory of æolian tones on the basis of vortex motions and confirms its conclusions by comparison with the well-known experimental results of Strouhal. [See Abstracts Nos. 294 (1912) and 1116 (1913).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1568. *Theory of Faraday-effect.* **P. Selényi.** (Phys. Zeitschr. 15. pp. 284–286, March 1, 1914.)—Describes a mechanical model for the qualitative and quantitative illustration of the Faraday effect. It consists of a weighted string along which a circular transverse wave is propagated. E. E. F.

1569. *Evaporation of Mercury Droplets suspended in a Gas.* **A. Schidlof** and **A. Karpowicz.** (Comptes Rendus, 158. pp. 1992–1994, June 29, 1914.)—The authors have previously experienced difficulty with experiments as to the value of the electron charge from the motion of mercury droplets between the plates of a condenser, in that the speeds of these drops become less with increase of time under given fields. They have now tried nitrogen as well as air between the condenser plates, and extended the time to over an hour. The speed-time graphs slope down in the same way for each gas, the speeds becoming less and less as time goes on. The reductions in an hour's time are to about a half in the case of air and to about one-fifth for nitrogen. It is also noticed that the droplets become more difficult to see as the experiments proceed. The conclusion adopted is that the droplets of mercury suffer evaporation under the action of the light. [See Abstract No. 848 (1913).] E. H. B.

1570. *Electric Conduction in Metals.* **F. Skaupy.** (Deutsch. Phys. Gesell., Verh. 16. 10. p. 494, May 30, 1914.)—Points out that a slip has been discovered in the previous work of the author under the above title [see Abstract No. 961 (1914)]. The full explanation and correction are reserved for a later communication. E. H. B.

1571. *Electric Charges less than that on the Electron.* **F. Ehrenhaft.** (Ann. d. Physik, 44. No. 5. pp. 657–700, June 19, 1914.)—A very full and elaborate account of this research which has previously been sketched in outline. [See Abstracts Nos. 282, 508, 947 (1911); 509 and 1300 (1914).] E. H. B.

1572. *Principle of Least Work in the Electrodynamics of Moving Bodies.* **J. Ishiwara.** (Ann. d. Physik, 42. No. 5. pp. 986–1000, Dec. 2, 1913.)—A discussion of the subject with special reference to the work of Henschke [Abstract No. 1252 (1913)].

1573. *Electrification Produced during the Raising of a Cloud of Dust.* **W. A. D. Rudge.** (Roy. Soc., Proc. Ser. A. 90. pp. 256–272, May 28, 1914.)—A continuation of previous work [see Abstracts Nos. 1182 (1913) and 336 (1914)]. The results of the present experiments confirm generally those given in the former papers. The raising of a cloud of dust is accompanied by the production of large charges of electricity. Some of the dust particles have positive charges, and others negative. Either one set of charged particles settles rapidly, leaving the other set in the air, or else a charge is given to the air itself. The experiments do not show which of these views is correct. The charge is retained by the air for some considerable time. The sign of the charge remaining in the air depends upon the nature of the material used. "Acidic" bodies, such as finely-divided silica or molybdic acid, give to the air a negative charge, whilst "basic" bodies, such as lead oxide, or organic dusts, such as flour or coal, give a positive charge. The total electrification of dust and air is zero. The friction between particles of similar material apparently produces sufficient electrification to account for the charges observed. An unweighable amount of dust can produce an easily measurable charge. A. W.

DISCHARGE AND OSCILLATIONS.

1574. *Photoelectric Effect of Carbon as Influenced by its Absorbed Gases.* **O. Stuhlmann** and **R. Piersol.** (Nature, 93. p. 454, July 2, 1914.)—The existing contradictory results on the photoelectric effect of carbon can be explained by means of the quantity and quality of the gases absorbed by the carbon. The influences of ammonia, hydrogen, air, and carbon dioxide are investigated. The most consistent results are obtained from carbonised bamboo and hydrogen. Saturation curves show ammonia to be the most active, and carbon dioxide the least. Distribution-of-velocity curves are obtained for bamboo and hydrogen. The maximum initial velocity is found to be independent of the quantity of hydrogen absorbed, while the maximum current is proportional to the quantity of gas absorbed. A. E. G.

1575. *Photoelectric Currents in Gases.* **A. Partzsch.** (Ann. d. Physik, 44. No. 4. pp. 556–584, June 4, 1914.)—The results of a number of measurements of the current through various gases obtained from a Pt-plate illuminated with ultra-violet light are given in which the field strength and pressure are varied between wide limits. These measurements confirm an early observation of Stoletow's that for a given gas the current is constant if the ratio of field strength (X) to pressure (p) remains constant provided no ionisation by collision is present. The curve connecting the current i with the ratio X/p for air and hydrogen was found to be of the form $i = i_1(X/p)^{0 \cdot 40}$, a form which the author shows to be such as would be expected from the mechanism of the conduction. Ohm's law as found by Stoletow is obeyed for low values of X/p. The author is, however, chiefly concerned with a comparison of the effects in various gases. A number of tables and curves are given for measurements at atmospheric pressure in air (damp and dry), CO_2, H, and O under various conditions as to the surface of the metal and the order in which the gases are used. In this way it was possible to eliminate to a certain extent the direct effect of the gas upon the photoelectric properties of the metal and thus to study the currents through the gases independently. The following results are obtained :—The current in CO_2 is greater than that in air for the higher values of the field, but smaller for the lower values ; it is continuously greater (*a*) in air than in hydrogen, (*b*) in damp air than in dry, and (*c*) in oxygen than in air. The ratio is a maximum in most cases for the intermediate field strengths. These results are discussed first from the point of view of the theories of conduction given by J. J. Thomson ["Conduction in Gases"] and by Bloch [see Abstract No. 959 (1910)]. These theories are in agreement with the Stoletow law but do not agree with the author's observations on the relative effects in different gases or with the comparison between the currents in a gas and a vacuum. The author advances the view that the number of ions which diffuse back, and therefore the current, depending as it does upon whether the ions exist as free electrons or as complex ions, depends on the electron-affinity of the gases. This explains qualitatively the order of the results, but needs to be tested further by experiments on electro-positive gases such as He, A, and N. F. J. H.

1576. *Energy of Photo-electrons from Sodium and Potassium as a Function of the Frequency of the Incident Light.* **W. H. Kadesch.** (Phys. Rev. 3. Ser. 2. pp. 367–374, May, 1914.)—The energy of photo-electrons as a function of the frequency of the incident light has been studied in numerous researches, but with little concordance of results. Ladenburg concludes that the emission velocity varies directly as the frequency. Joffé showed, however, that Ladenburg's observations were in quite as good agreement with the view that not the velocity of electrons but their energy, varies as the frequency. Kunz at first found a linear relation between energy and wave-length. Later observations led him to develop a theory according to which the velocity varies as the frequency. Wright found a maximum in the energy curve and this was taken as a confirmation of the view that the photoelectric effect is a resonance phenomenon. The same conclusion had been reached by Lenard and by Ladenburg and Markau. Hughes found a linear relation between energy and frequency, as did also Richardson and Compton. Cornelius obtained results which were taken to support the theory of Kunz. Compton, however, showed that according to Cornelius' data the energy is more nearly proportional to the cube of the frequency than to the square. It was with the hope of eliminating some of the difficulties and errors that beset investigators in this field that the present research was undertaken. The chief sources of uncertainty in photoelectric work have been the following: (1) The illuminated surfaces have usually been of metals sensitive to only a short range of frequencies. (2) Surface conditions have not been controlled, so that there was no assurance of uniformity throughout a set of observations. (3) There has been in some cases much trouble with reflected light. In order, as far as possible, to obviate these difficulties, surfaces of the strongly electro-positive metals, sodium and potassium, are illuminated, these being sensitive to long waves as well as short, a device being employed for exposing a fresh surface very readily, and as often as desired. The apparatus used is described in detail. The results of the investigation are in agreement with those of Hughes and of Richardson and Compton. They may be expressed by an equation of the form $V = K_n - V_0$ in which V is the p.d. in volts between the electrode and the adjacent parts of the tube, just sufficient to prevent a deflection of the electrometer, n is the frequency of the incident light, and K and V_0 are constants. According to Einstein's theory the relation between energy and frequency should be represented by the equation $Ve = R\beta n/N - P$ in which e is the elementary electrical charge, $R\beta/N$ is Planck's constant equal to $6{\cdot}55 \times 10^{-27}$, and P a constant representing the loss of energy suffered by an electron escaping from the metal. The observations on sodium gave a value for K equal to $3{\cdot}87 \times 10^{-15}$, those on potassium $3{\cdot}88 \times 10^{-15}$. Writing the equation in the form given by Einstein, and substituting for e, $4{\cdot}772 \times 10^{-10}$, the slope for sodium becomes $6{\cdot}16 \times 10^{-27}$, that for potassium $6{\cdot}09 \times 10^{-27}$. It is shown that the total observational error would not account for a difference as large as that between the slopes of the experimental curves and that of Einstein's formula. A. E. G.

1577. *Effect of Space Charge and Residual Gases on Thermionic Currents in High Vacuum.* **J. E. Lilienfeld.** (Phys. Rev. 3. Ser. 2. pp. 364–365, May, 1914.)—A reply to Langmuir's paper [see Abstract No. 725 (1914)].

1578. *Powerful Röntgen Tube with a Pure Electron Discharge.* **J. E. Lilienfeld.** (Phys. Rev. 3. Ser. 2. p. 366, May, 1914.)—A reply to Coolidge's paper [see Abstract No. 564 (1914)].

1579. *Experiment Illustrating Spatial Density of Electrons.* **F. L. Hopwood.** (Electrician, 73. p. 700, July 31, 1914.)—The experiment is the outcome of one previously described by A. S. Eve and by the author [Abstract No. 942 (1914)]. If the temperature of the lamp filament is raised by over-running the lamp a negatively charged rod no longer causes a displacement of the filament. That this is due to the spatial density of the electrons having the effect of diminishing the possible electron current [see Abstract No. 725 (1914)] is shown by means of a lamp containing two separate filaments. When one filament only is heated the effect is shown, but when the electron density is increased by heating the second filament the effect no longer exists. By heating one filament only and using the lamp as a Fleming valve the effect was shown not to be due to the production of positive electricity. F. J. H.

1580. *Electrification by Röntgen Rays.* **C. G. Bedreag.** (Comptes Rendus, 159. pp. 169–171, July 3, 1914.)—The author has previously pointed out that the charge obtained on a metallic electrode exposed to Röntgen radiation changes, with variation of pressure around the electrode, from a negative value at high pressures to a positive value in a vacuum [see Abstract No. 1706 (1913)]. If the negative charge were due to a difference in mobility of positive and negative ions, then in CO_2 the charge should be very much diminished owing to equal mobility of the ions. This is not found to be the case. When the distance *r* of the electrode from the anterior wall is varied, the charge Q may be represented by $Q = Q_0 e^{-ar} + K/d^2 \pm hE$; Q_0 being the kathodic emission from the anterior wall, *a* the coefficient of diffusion, *k* the positive effect upon the same electrode, *d* the distance of the electrode from the antikathode of the Röntgen tube, and $\pm hE$ an effect due to chemical variation of the surface of the electrode. The influence of the intensity of the radiation, and homogeneous Röntgen radiations are also considered.

A. E. G.

1581. *Nature and Velocity of Migration of the Positive Ions in Flames.* **A. H. Saxer.** (Phys. Rev. 3. Ser. 2. pp. 325–338, May, 1914.)—Measurements of the velocity of migration in an electric field of the positive ions introduced into a colourless Bunsen flame by the volatilisation of an alkali salt in it have given widely divergent results. Thus, Lenard obtained a value of 0·08 cm. per sec. for the positive ions produced by lithium, whereas Lusby arrived at the velocity 350 cm. per sec. for the positive ions of all alkali salts at about 1950° abs. The author has therefore constructed an apparatus, with which he has made a number of measurements with various salts of the alkali metals. The results show that the max. velocity of the positive ions of the colourless Bunsen flame is 1·8 cm. per sec. when measured in the flame itself where the temperature is 1250° C., and 2·5 cm. per sec. when measured in hot air at 475° C.; these ions have their velocities reduced in the presence of alkali salt vapours. The velocity of the positive ions of the various alkali salt vapours is less than the velocity of the positive ions of the pure flame. These ions are the nuclei of large molecular aggregates and they carry with them the spectrum of the metal used in their production. T. H. P.

1582. *Magnetic Rays in Various Gases and Gas Mixtures.* II. **A. Righi.** (N. Cimento, 7. Ser. 6. pp. 208–250, April, 1914. Phys. Zeitschr. 15. pp. 558–568, June 1, 1914.)—A continuation of previous work [Abstract No. 529 (1914) and Phys. Zeitschr. 15. p. 528, 1914]. The virtual anode effect is considered in the following gases: Hydrogen, oxygen, CO_2, CO, nitrogen, ether vapour, chloroform vapour, and mixtures of pairs of these gases. The results are described in detail with the help of diagrams, and in opposition to the views of More and Mauchly [Abstract No. 1995 (1913)] the author considers that his neutral pair theory gives the simplest explanation of the phenomena. [See also Abstract No. 1471 (1913).] A. W.

1583. *Ionisation by Collision in Mercury Vapour.* **J. Franck** and **G. Hertz.** (Deutsch. Phys. Gesell., Verh. 16. 10. pp. 457–467, May 30, 1914.) In a previous paper [Abstract No. 659 (1913)] the authors investigated the ionisation potentials for various gases, and showed that it had a definite magnitude for each gas. Measurements were made with He, Ne, Ar, H, O, and N. In the present paper the authors deal with collisions between electrons and molecules of mercury vapour and the ionisation potential for this vapour. A new method of measuring the ionisation potential was employed, and is described in detail. It is shown that the electrons in mercury vapour undergo elastic collisions with the molecules up to a critical velocity. A method is described whereby this critical velocity may be measured accurately to a tenth of a volt. In the case of mercury vapour the critical velocity is equal to that which the electrons possess with a fall of potential of 4·9 volts. It is shown that the energy of a 4·9-volt ray is very nearly the same as the energy-quantum of the mercury resonance line λ2536. The results are discussed, and it appears that in the giving-up of energy of the 4·9-volt ray to the mercury molecule a part of the impact leads to ionisation, from which it is deduced that 4·9 volts is the ionisation potential of mercury vapour. Another part apparently gives rise to emission of light, presumably the line of wave-length 2536. Further research in this direction is in progress. A. W.

1584. *Excitation of Mercury Resonance Line λ 2536 by Electron Collisions.* **J. Franck** and **G. Hertz.** (Deutsch. Phys. Gesell., Verh. 16. 11. pp. 512–517, June 15, 1914.)—A continuation of previous work [see preceding Abstract]. Using a Pt-wire heated by an electric current as a source of electrons in a quartz chamber containing mercury vapour, the authors were able to show that the mercury line λ2536 was excited by the electron collisions, under the conditions obtaining in their experiments. From the research on the collisions between electrons and mercury atoms the following conclusions are drawn:—(i) The electrons are reflected by the mercury atoms without loss of energy, so long as their kinetic energy is smaller than the amount $h\nu$, where ν is the frequency of the corresponding resonance line. (ii) As soon as the kinetic energy of an electron has reached the value $h\nu$ this energy-quantum is at one of the next collisions of the electron transferred to the atom spectrum of frequency ν. (iii) The transferred energy is partly used in producing ionisation and partly results in the emission of light of frequency ν. (iv) The value of h given by the present researches is $6{\cdot}59 \times 10^{-27}$ erg sec., with a possible error of 2 %. A. W.

1585. *Velocities of Photo-electrons.* **G. A. Dima.** (Comptes Rendus, 158. pp. 1573–1575, June 2, 1914.)—The measurements were made by the ordinary method of determining the potential necessary to stop the photo-electrons, contact difference of potential being measured by a special arrangement and allowed for. The results so far obtained agree closely with those of Compton [Abstract No. 1465 (1913)]. E. M.

1586. *Production of Light by Kathode Rays in Hydrogen.* **J. Holtsmark.** (Phys. Zeitschr. 15. pp. 605–608, June 15, 1914.)—Kathode rays from a lime kathode in hydrogen are sent through a slit into an enclosed cylinder so as to free them from the influence of an electric field. The light produced is split up into its spectrum and photographed, the relative intensities of the lines H_β and H_γ being compared in the manner described by Kock [Abstract No. 873 (1910)]. With a possible error of 20 % the relative intensity is independent of the kathode-ray velocity over a voltage range of from 20 to 1700 volts. It is, however, dependent upon the gas pressure, the lines towards the red end of the spectrum becoming relatively stronger than those towards the violet end with increasing pressure. No change in the relative intensity with current density was observed over the range of 0·5 to 32 milliamps., although the pressure effect appears to be different for different currents. The effects observed are similar to those described by Vegard [Abstracts Nos. 113, 1183, 1473 (1913)] for the negative glow and for the light produced by canal rays. F. J. H.

1587. *Limiting Potentials with Cylindrical Electrodes.* **W. Schottky.** (Deutsch Phys. Gesell., Verh. 16. 10. pp. 490–494, May 30, 1914.)—When electrons are emitted from an earthed hot wire, the receiving electrode charges itself to a limiting positive potential. In the case of a hot wire stretched along the axis of a cylinder, the author shows how to calculate limits within which the max. potential must lie, the lower limit being calculated on the assumption that no electrons are reflected from the cylinder, the upper limit on the assumption that the density of the free charge between the wire and cylinder vanishes. J. R.

1588. *Current between an Incandescent Filament and Coaxial Cylinder.* **W. Schottky.** (Phys. Zeitschr, 15. pp. 624–630, June 15, 1914.)—The relationship $\Phi = (9JR/2\sqrt{2}\gamma)^{2/3}$ has been obtained by Langmuir [Ibid. p. 348, also p. 516 (1914)], and independently by the author [see preceding Abstract] for the p.d. Φ needed to send an electron current J from a thin incandescent filament per unit length to a concentric cylinder of radius R, γ being the ratio of the charge to the mass of the electron. A careful mathematical investigation shows that certain corrections arising from the spatial density of the electrons are needed for the lower potentials. Limiting values for these corrections are given, from which, conditions favourable to the validity of the relationship are deduced. Measurements with tungsten, tantalum, and carbon filaments in cylinders of different radii show the approximate validity of the expression for potentials below 11 volts, the departures having the expected characteristics. In the case of the carbon filament it is very difficult to obtain good curves, a fact which is probably explained by the emission of positive ions. The action of the space charge is increased by the presence of hydrogen below the sparking potential, but above this potential the effect is more or less nullified. [See also next Abstract.] F. J. H.

1589. *Emission of Electrons from an Incandescent Filament under the action of a Retarding Potential.* **W. Schottky.** (Ann. d. Physik, 44. No. 7. pp. 1011–

1082, July 17, 1914.)—The paper is both a theoretical and an experimental investigation into the electron current between an incandescent filament and a coaxial cylinder in an extreme vacuum under the action of a retarding potential. The theoretical calculation is made on the assumption that the electrons are emitted from the filament with velocities distributed according to the Maxwell law. With the stronger electron currents, *i.e.* with the smaller retarding potentials, a diminution of the current arising from the retarding forces called into play by reason of the spatial density of the electrons is taken into consideration, expressions being given for obtaining superior and inferior limits to the value of the potential at which the action begins. The experimental curves obtained for carbon and tungsten filaments agree well in most cases with the theoretical curves for values of the current for which the spatial density produces no effect, thus verifying the application of the Maxwell law. There are, however, in the region of the higher electron velocities certain departures from the theoretical values which lie outside the limits of experimental error. In addition to the above a contact p.d. between the hot wire and the cylinder is considered, and shown to exist experimentally. By means of experiments with cylinders of different materials the contact p.d.'s between these at ordinary temperatures could be obtained. These agree well with well-known measurements in ionised air. F. J. H.

1590. *Electrodeless Ring Discharge in Mercury Vapour.* **J. v. Kowalski.** (Phys. Zeitschr. 15. pp. 249–250, March 1, 1914.)—A quartz bulb filled with mercury vapour shows in an electric alternating field a brilliant white glow at 60° and an emerald green glow at 140°. This confirms the result of Wachsmuth and Winawer [Abstract No. 186 (1914)] that mercury vapour, like other gases, has two ionisation energies. The two forms of glow can be exhibited by simply heating and shaking the bulb. E. E. F.

1591. *Theory of Glow Discharge.* **R. Holm.** (Phys. Zeitschr. 15. pp. 241–249, March 1, and pp. 289–298, March 15, 1914.)—Assumes, with J. Franck, that electrons suffer inelastic reflections from molecules, the loss being the greater the slower the electrons. The absorption of electrons by neutral molecules is much more frequent than their recombination. A portion of the energy of impact is liberated in the form of a radiation which allows of an increase of the ionisation by collision. These hypotheses are worked out to what is claimed to be a satisfactory theory of the stratified and unstratified glow discharge. E. E. F.

1592. *Discharges in Geissler Tubes and Spectral Effects Produced.* **M. Millochau.** (Journ. de Physique, 4. Ser. 5. pp. 206–221, March, 1914. Paper read before the Soc. franç. de Physique.)—A comparative study of the discharge in a Geissler tube and the corresponding spectrum obtained. The method consists in photographing both the discharge (by a rotating film) and the spectrum produced by it (by a spectrograph) at the same time. The discharge is usually produced by a condenser, capable of being charged to 15,000 volts, oscillatory discharges being obtained by inserting a self-induction in the condenser circuit. The author classifies the discharges, both continuous and oscillatory, according to their duration and from the point of view of the spectral effects obtained. In such tubes the discharge occurs if the potential rises above a superior limit V_s, and ceases when the potential is lowered past an inferior limit V_i. The results obtained are explained on the supposition that the spectrum tube possesses a large capacity in virtue of the discharge, and it is shown that when the discharge is oscillatory the expenditure of energy in the tube is such that the charge of the system is lowered by a constant quantity each oscillation whatever be the period. When the discharge is continuous the circuit acts like a metallic circuit of which the resistance is equal to that employed multiplied by a constant coefficient. Thus a spectrum tube is characterised by five constants: V_s, V_i, the apparent capacity, the coefficient of resistance (ρ), and the fall in potential per oscillation of the charge passing. The mean energy expended per unit time can be calculated, giving, for the slow discharge, $(\rho - 1)\ C(V^2 - V_i^2)/t$, where C is the capacity of the condenser used, V the initial potential, and t the duration of the discharge; and for the oscillatory discharge $C(V^2 - V_i^2)/nT$, where n is the total number of oscillations of period T. For a tube containing hydrogen it is found that for the continuous discharge, the mean energy utilised per sec. is between 800 and 8600 joules, when the line spectrum (stellar series) with sharp lines is observed. With the oscillatory discharge, duration $\frac{1}{100}$ to $\frac{1}{1000}$ sec., the value is between 8000 and 82,000 joules, and the lines are slightly diffuse, becoming more so as the energy expended per sec. increases. When the value is greater than $8{\cdot}2 \times 10^{14}$ joules, the duration of the discharge being less than $0{\cdot}8 \times 10^{-6}$ sec., the spectrum is continuous with maxima in the places of the lines of the stellar series.

The author concludes that the spectrum given by a tube depends uniquely upon the quantity of energy transformed in it per sec. T. H.

1593. *Electric Brush Discharge in Weak Acids and Solutions.* **H. Smith.** (Phil. Mag. 27. pp. 801–823, May, 1914.)—The changes which occur in the spectra of the electric brush discharge in solutions under varying electrical conditions have been investigated in a previous paper [Abstract No. 1881 (1913)]. In the experiments there discussed the brush in all cases was alternating, and observations were confined to the visible region (λ6700 to λ4200). The present research was undertaken to extend the observations into the ultra-violet region and to investigate the differences which may occur between the positive and negative brush. A large number of solutions were examined but only the uncondensed brush was used. The results of the investigation may be summarised as follows:—The series and secondary spectrum of hydrogen are a great deal brighter in distilled water than in solutions for the same current value. In distilled water they are stronger in the negative brush than in the positive for the same current. When the potential drop through the brush is the same in each case, the spectra are strongest in the positive brush. In solutions, the intensity of the spectra relative to the rest of the brush spectrum (water-vapour bands, Pt, and oxygen lines, etc.) is considerably diminished. Neither the nature of the solution nor the sign of the brush has any perceptible effect. There is no certain indication that electrolysis plays any part in the appearance of the spectra. The spectrum of the metallic lines of the solute appears in the negative brush in solutions. For constant current the spectrum grows in intensity with the concentration till a certain value of the concentration is reached, when no further increase occurs. The spectrum appears in the case of the positive brush in the strongest solutions, and then only very faintly. The behaviour of the spectrum in all cases can readily be explained from the point of view of electrolysis. The elementary line-spectrum of oxygen appears in distilled water in both the positive and negative brush. In dilute acids solutions of Mg and Zn sulphates, and in tap water, it appears in strength in the positive brush, but is generally absent or very weak in the negative. In solutions of the salts of Li, Na, and K, its appearance in the positive brush is the same as for other solutions; in the negative brush the spectrum appears with the metallic lines of the salt, increases in intensity with them, and reaches its maximum with the same concentration of solution. The negative bands of nitrogen behave in the same manner. In the negative brush both the positive and negative bands appear in general remote from the point, while the oxygen lines are always produced close to the point. The arc spectrum of Pt appears in the negative uncondensed brush. In the condensed brush the spark lines appear. When copper wire is used in the point electrode the copper lines appear in each brush but are stronger in the negative. The water-vapour bands appear in each brush equally well.

A. W.

1594. *Diffraction of Electric Waves at a Dielectric Cylinder.* **Kobayashi-Iwao.** (Ann. d. Physik. 43. No. 6. pp. 861–898, March 20, 1914.)—The experiments of Schaefer and Grossmann [Abstract No. 720 (1910)] on dielectric currents and resonance yielded results which did not quite agree with theory. The mathematical theory is now given more fully, and is shown to be in complete agreement with experiment.

E. E. F.

1595. *Discharge of Electricity from Cylinders and Points.* **J. S. Townsend** and **P. J. Edmunds.** (Phil. Mag. 27. pp. 789–801, May, 1914.)—Watson has investigated discharges through air at pressures varying from 1 atmo. to 0·5 atmo. and with wires between 12·8 and 0·7 mm. diam. Townsend [Abstract No. 1332 (1913)] found that an explanation of Watson's results could be obtained on the hypothesis that the ionisation was due to collision, as had previously been found for discharges between parallel plates at low pressures. The present investigation was undertaken to test the theory over a range of pressures of air from 1 mm. to 760 mm. with wires of various diameters. Two cylinders of brass were used; a large one, internal diam. 14·9 cm. and effective length 66 cm., and a smaller one, internal diam. 8·96 cm. and length 44 cm. The ends were closed with thick glass discs through the centres of which wires of various diameters could be inserted and fixed. For details of apparatus and method of operation see original paper. On the hypothesis that the sparking potential is determined by ionisation by collision, it is found that the sparking potential V for a pair of cylinders of radii a and A when the pressure is p is the same as that for a pair of cylinders of radii ka and kA when the pressure is p/k. Hence, if X_1 is the electric intensity at the surface of the inner cylinder, aX_1 is constant when ap is constant for pairs of cylinders which are geometrically similar. The condition that X_1 should be independent of the radius of the outer cylinder is that X_0/p should be less than 40, X_0 being the intensity at the outer cylinder. This condition was satisfied in the experiments, and so theory gives the simple result that aX_1 should be the same for all wires for the same value of ap. To test this a curve, giving the relation between the sparking potential and the pressure, was drawn for each wire; these curves were found to be quite regular. Watson's results may be represented in a similar manner. In general a marked difference was found between the sparking potentials when the wire was charged positively and when the wire was charged negatively. At the smaller values of ap the sparking potential was found to be lower when the wire was negative than when it was positive, but with values of ap from about 5 to 20, a lower potential was required to produce a positive discharge.

Experiments were also made with blunt points, the discharge passing from these to planes. Observations were also made of the relation of the rise in potential to the current, and also of the effect of moisture. It was found that the increase of potential required to maintain a given negative discharge depended on the dryness of the air. Theory shows that the potential v required to maintain a small current I is given by the formula—

$$v(v - V) = [IA^2 \log A/a]/2k,$$

k being the velocity of the ions under unit electric force, and V the sparking potential. The potentials v required to maintain small currents were quite consistent with this expression, but no very accurate determinations of k have yet been deduced from the observations. It was found that dI/dv was smaller for positive than for negative discharges. Also when the air was damp, dI/dv for negative discharges diminished, showing that the negative ions, in the space in which X/p is small, are affected by the moisture. But in the space near the inner cylinder where X/p is large the negative ions are not affected by the moisture, since the sparking potentials are the same for moist and dry gases. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1596. *Positive and Negative Temperature Coefficient of the Resistance of Non-electrolytic Conductors.* **F. Streintz.** (Ann. d. Physik. 44. No. 4. pp. 545–555, June 4, 1914.)—The author and also other investigators have usually found that the electrical resistances of compressed, powdered metallic oxides, sulphides, etc., diminish with rise of temperature. This may, however, not be actually a property of the material itself, but may be due to the over-compensation of the positive resistance coefficient by the negative coefficient of the transition resistance set up at the surface of separation of the conductor and the circuit. That non-electrolytic conductors, like compact metals, have positive temperature-coefficients of resistance is rendered probable by the results of experiments with pressed platinum black, which demonstrate the great influence exerted by the transition resistance of a powder on the apparent temperature-coefficient. T. H. P.

1597. *Resistance of Crystallised Antimony.* **W. J. de Haas.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 1110–1128, May 29, 1914.)—Thin plates of antimony were split off along cleavage planes, immersed in shellac, and polished into small rods. The resistance of such rods at temperatures (θ) down to that of liquid air could be expressed by means of the formula: $R = R_0(1 + \alpha\theta + \beta\theta^2)$. The resistance of antimony was also measured at 18° in a field of 28 kilogauss with various angles between the direction of the field and the principal axis of the crystal. The ratio of the resistance in the field to that with no field can be expressed for all temperatures by a formula of the form: $R'/R = a - b \sin c\,(d - H)$, where a, b, and d are constants. It is concluded that the field has a directing influence on the diamagnetic metal molecules, and that there exists a connection between crystal system, resistance change, and diamagnetic susceptibility. [See also Abstracts Nos. 74 (1900) and 115 (1907).] G. E. A.

1598. *Electric Resistance of Crystals and Residual Electromotive Forces.* **P. Collet.** (Comptes Rendus, 158. pp. 1994–1997, June 29, 1914.)—An experimental research from which the following conclusions are drawn:—(1) The contact is of preponderating importance, in finding the absolute value of the resistance. If the contact is satisfactory the phenomena are much simpler and more regular. (2) There is a residual e.m.f. of sense opposite to the current through the crystal, and the polarisation effect may be referred to thermoelectric phenomena. E. H. B.

1599. *The Action of Light on Selenium.* **W. S. Gripenberg.** (Phys. Zeitschr. 15. p. 462, May 1, 1914.)—An account of experiments which indicate that the action of light on selenium extends deeply into the interior of the substance. J. J. S.

1600. *Contact Potential in Vacuum.* **W. Schottky.** (Deutsch. Phys. Gesell., Verh. 16. 10. pp. 482–485, May 30, 1914.)—Describes by a diagram a method for the exact determination of contact p.d. in a vacuum and discusses its difficulties. E. H. B.

1601. *Pyro-electricity.* **S. Boguslawski.** (Phys. Zeitschr. 15. pp. 283–288, March 15, 1914.)—To explain deviations from the Clausius-Mosotti formula for dielectrics, the author gives up the conception of quasi-elastic displacements, and represents the work of displacement by a series of terms $ax^2 + bx^3 + cx^4$, where x is the displacement, and a is always positive. The fourth-power term produces a diminution of the quantity $(\epsilon - 1)/\rho(\epsilon + 2)$ with increasing temperature if $c > 0$, or an increase if $c < 0$. It produces a very small deviation from the proportionality of displacement and field intensity. The cubic term produces a polar pyro-electric effect, and also a polarity of dielectric properties, which, however, is excessively small.
E. E. F.

1602. *Thermo-junction of Carbon and Graphite.* **C. C. Bidwell.** (Phys. Rev. 3. Ser. 2. pp. 450–452, June, 1914.)—A thermo-junction of carbon and graphite designed to measure the temperature of molten metals beyond the reach of the Pt and Pt-Rh thermocouple is described [see Abstract No. 1563 (1914)]. Rods of carbon and graphite 30 cm. long and 2 mm. diam. have pointed ends which are brought close together in the molten metal. The cold ends are fitted to heavier rods 50 cm. long which are connected by copper leads to the galvanometer. The e.m.f. of the couple is large, being approx. 0·02 microvolt per deg. and is nearly linear up to 2000° C. It is, however, somewhat erratic unless the rods are previously heated up to 2000° C. at which temperature all impurities affecting the e.m.f. are given off. When the couple is used in air the rods gradually oxidise just above the surface of the molten metal, so that new points have occasionally to be made. A disadvantage of the couple is that when this occurs owing to the heterogeneity of the materials a new calibration is needed. Curves are given showing a series of calibrations after re-pointing. If rods of greater purity protected from oxidation were used a serviceable instrument might be made.
F. J. H.

1603. *E.M.F. between Portions of the Same Metal at Different Temperatures.* **H. Hörig.** (Phys. Zeitschr. 15. pp. 388–393, April 15, 1914.)—A theoretical discussion of the author's previous experiments on the e.m.f. due to temperature gradient in a metal [see Abstract No. 1116 (1914)]. A more accurate measurement of this effect may lead to a decision as to the admissibility of certain hypotheses with regard to the transfer of electricity and the nature of the Thomson-effect. J. J. S.

1604. *Thermoelectric Properties of Selenium-Antimony Mixtures.* **H. Pelabon.** (Comptes Rendus, 158. pp. 1669–1671, June 8, 1914.)—Comparison of the thermoelectric powers of couples consisting of Pt and mixtures of Se and Sb confirm the existence of only one compound between these two elements, Sb_2Se_3, the thermoelectric power of mixtures containing less Se than this being little different from that of pure Sb, but suddenly increasing more than ten times as the composition required by Sb_2Se_3 is reached. With larger proportions of Se, the thermoelectric power remains about that of Sb_2Se_3. The latter reaches a maximum at a temperature of about 700° C., that of the cold junction being kept at 11° C. [See also Abstract No. 1401 (1911).] W. H. Si.

1605. *Thermoelectric Power of Tin Selenides.* **H. Pelabon.** (Comptes Rendus, 158. pp. 1897–1900, June 22, 1214.)—The existence of the two compounds SnSe and $SnSe_2$ is confirmed by determination of the thermoelectric powers of couples consisting of Pt and alloys of Sn and Se. Both compounds have a high thermoelectric power, increasing rapidly with rise in temperature of the hot junction, but being opposite in sign, the current passing from $SnSe_2$ to Pt through the hot junction. They are good conductors, melt at relatively high temperatures, and are very suitable for the production of sensitive thermopiles. W. H. Si.

1606. *The Actino-dielectric Effect.* **F. Schmidt.** (Ann. d. Physik, 44. No. 8. pp. 477–496, May 26, 1914. Abstract of Part 2 of Dissertation, Heidelberg.)—[See Abstracts Nos. 878 (1909) and 726 (1905).] The actino-dielectric effect on a thick layer of a Ca-Bi phosphorus was first measured for different wave-lengths of light. A maximum of the effect was found in the red, and two minima at 820 and 420 $\mu\mu$. These minima occur for the wave-lengths at which the natural emission of light from the phosphorus is a maximum. Hence the conclusion is drawn that the correct relation between the actino-dielectric effect and wave-length of light has not been obtained, for these minima are due to the light being absorbed in the upper layers of the phosphorus, thus leaving the lower layers still non-conducting. To get a correct relation, thin transparent layers and not thick opaque layers must be used. With such thin layers one maximum was found at 580 $\mu\mu$ and one minimum at 480 $\mu\mu$. The use of thin films also gives some idea as to the nature of the conduction produced in the phosphorus by light. A thick opaque layer cannot be made wholly conducting, and the only effect that can be observed with such is of the nature of a dielectric polarisation. With thin transparent layers it was shown that the conduction is of the nature of an electrolytic effect. Apparently the molecules of the phosphorus are decomposed by light and the ions thus formed account for the conduction. When the light is removed the ions recombine and soon the material becomes a dielectric again. J. R.

1607. *Thermoelectrics of Strained Wires.* **J. M'Whan.** (Roy. Soc. Edinburgh, Proc. 34. pp. 64–68, 1913–1914.)—It has been shown that curves of thermoelectric force are, for many metals, parabolas whose axes are inclined at very small angles to the e.m.f.-axis [see Abstract No. 670 (1911)]. The author describes experiments made on a thermo-couple consisting of two pure nickel wires, one unstretched and the other subjected to any desired tension, while an approximately constant temperature-difference of 75 deg. C. was maintained between the two junctions. The curve connecting tension with the e.m.f. developed was found to be parabolic, with the axis inclined at an angle of nearly 4° with the e.m.f.-axis, the maximum point observed being $17{\cdot}868 \times 10^{-6}$ volt at a tension of 11 kg. Previous similar experiments on non-magnetic metals nearly all gave a straight line up to the point where overstrain set in. J. W. T. W.

1608. *Silver and Iodine Voltameters.* **S. J. Bates** and **G. W. Vinal.** (Amer. Chem. Soc., Journ. 36. pp. 916–937, May, 1914.)—An account of a careful comparison of the silver and iodine voltameters using them in series, so that the deposits of silver and iodine should be strictly comparable. The best procedure learned from previous investigations has been followed in each case. The results are as follows:—

1. Ratio of silver to iodine	0·85017
2. Electrochemical equivalent of iodine	1·31502
3. Value of the Faraday (I = 126·92)	96,515
4. Value of the Faraday (Ag = 107·88)	96,494
5. Value recommended for general use	96,500

The work was carried out at the Bureau of Standards. F. E. S.

1609. *The Silver Voltameter.* **W. Jaeger** and **H. v. Steinwehr.** (Elektrotechn. Zeitschr. 35. pp. 819–820, July 16, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—The advantages and disadvantages of the various forms of silver voltameters are briefly discussed, and some remarks made by Rosa, McDaniel, and Vinal [see preceding Abstract] are criticised. The authors believe the Kohlrausch form of voltameter to be quite satisfactory, and that silk may be used to envelop the anode if necessary. The "volume effect" in voltameters (*i.e.* the obtaining of a heavier deposit in a large voltameter than in a smaller when an impure electrolyte is used) is doubted. F. E. S.

1610. *Use of the Telephone as an Oscillograph.* **M. Siegbahn.** (Phil. Mag. 27. pp. 909–914, May, 1914.)—It has frequently been proposed to use the telephone for the study of variable currents, as it would seem probable that the membrane will reproduce the variations of the current most accurately. It is known that even small peculiarities in a person's voice or speech can be recognised through telephonic transference. In a telephone under ordinary conditions the amplitude is of the dimension of 0·0001 mm., and experience shows that speech transference is good only under these circumstances. Increasing the amplitude so that normal registering apparatus can give measurable deviations affects the accuracy of reproduction. Finally, good acoustical transference does not guarantee that the mechanical vibrations are identical with the electrical variations, nor do they even give a sufficiently good copy of them.

The author has previously described [Abstract No. 291 (1914)] a method for recording the vibrations of, say, 0·001 mm. with sufficient accuracy. Since the above-mentioned paper, the apparatus has been greatly improved. It consists of two coaxial microscopes, the first of which gives a greatly diminished ($\frac{1}{100}$) image of an illuminated slit 1 mm. broad. A sharp edge is mounted on the telephone diaphragm, which is placed in the image so as to screen off a great portion of the light ($\frac{9}{10}$). The rest passes through the other microscope and forms a magnified image on a photographic plate. While the membrane vibrates, the edge will screen off more or less of the first image, which will cause a corresponding variation in the light-intensity of the image on the plate. On moving the plate perpendicular to the ray of light there will be sections with different brightness giving dark or bright lines on developing the plate. The darkness of the plate is a measure of the corresponding deviation of the membrane. In order to give a complete representation of the vibrations the darkness of the plate must be continually recorded. One of the methods used by the author was to allow the light to fall on a thermopile, the thermoelectric force being measured by a recording galvanometer. On moving the photographic plate slowly the galvanometer registers a curve where the deviations are approximately proportional to the degree of darkness of the different sections, that is, proportional to the deflections of the membrane. A number of oscillograms taken in this way are reproduced in the paper. The results show that the free vibrations of the membrane interfere greatly with the true reproduction, and rapidly varying effects cannot be examined in this way. The general conclusion reached is that the telephone cannot be used for oscillographic purposes. [See, however, Guyau, Abstract No. 1056 (1913).] H. H. H.

1611. *New Type of Thermogalvanometer.* **F. W. Jordan.** (Phys. Soc., Proc. 26. pp. 165–171; Discussion, p. 171, April, 1914.)—The puff of air from an orifice in an air chamber when the air within is suddenly heated is utilised in this instrument to deflect a small suspended vane. The current to be measured is made or broken through a heater of small thermal capacity in the air chamber and the outrush or inrush of air through the orifice delivers an impulse to the vane. The disturbing effects of extraneous heat and pulsations of external pressure are eliminated by a compensation method. In one instrument of this type the sensibility was 4 mm. per microwatt and the extremity of the throw of the vane was attained in 2 secs. AUTHOR.

1612. *Cascade Attachment for Graphite Furnace.* **E. F. Northup.** (Metallurgical and Chem. Engin. 12. pp. 305–306, May, 1914.)—Since everything tends to evaporate more rapidly under diminished pressure it appears to the author that it is wrong to use a vacuum furnace for the highest temperatures, and he has attempted to obtain a furnace in which high pressures and an inert atmosphere can be obtained by the use of large masses of graphite which are heated electrically. The device consists of a graphite resistor surrounded by a graphite tube, the whole being fixed in the chamber of the high-temperature graphite furnace previously described by the author [Ibid. pp. 31–33, Jan., 1914]. The outer furnace is first heated up to 1600° C. by a current of 5 kw. when the current is switched on to the resistor, the input being then raised to 8 or 9 kw. In this way a temperature of 3000° C. can easily be obtained inside the resistor, and since the temperature is produced in steps the arrangement has been called a "cascade" attachment. A graphite crucible can be placed inside the resistor for the fusion of such metals as tungsten, etc. F. C. A. H. L.

ALTERNATING CURRENTS AND MAGNETISM.

1613. *Permeability at Low Induction Densities.* **A. F. Wagner.** (Phys. Zeitschr. 15. pp. 587–591, June 1, 1914.)—An application of Burrows' compensated double-bar and yoke method in which two short bars are connected by yokes and a compensating magnetomotive force is applied to the yokes and connections to balance the reluctance of this part of the circuit.

Measurements made with fields down to 0·005 gauss show that the method is applicable to low induction measurements, and B and H curves for four specimens show a uniform rise of B with H apparently from a zero at the origin. For the system of coils employed, the paper should be consulted. [See Abstract No. 525 (1911).] G. E. A.

1614. *Foucault Currents in Iron Anchor-ring.* **A. Defretin.** (Comptes Rendus, 158. pp. 1885–1887, June 22, 1914.)—When an anchor-ring is magnetised by means of an alternating current, its permeability being supposed constant, the mean induction for a given current is given by a complicated expression. From this expression two limiting laws are derived, viz. (1) the effective mean induction for a given current is inversely proportional to the square root of the frequency, if the latter is sufficiently great; (2) the effect of hysteresis is to cause a definite lag in the mean induction. These laws have been verified experimentally, for frequencies varying between 81 and 51. [See also Abstract No. 1239B (1913).] G. E. A.

1615. *Effect of a Magnetic Field on Metallic Resistance.* **W. A. Jenkins.** (Phil. Mag. 27. pp. 781–789, April, 1914.)—The metal examined was nickel which was used in the form of a short piece of very fine wire soldered at right angles to the ends of two thick copper wires and placed between the poles of an electromagnet. A Wheatstone bridge method was used for measuring the resistance and the temperatures of experiment were 18° and 98·5° C. Hysteresis curves for both longitudinal and transverse fields were obtained. The effect in a transverse field was found to consist of two parts: the first gives an increase and reaches a maximum; the second gives a decrease and does not reach a maximum. The longitudinal effect and the first part of the transverse effect possess similar characteristics. There is some relation between the dimensional change in a magnetic field and the resistance effect; one, however, is not the cause of the other, but both are probably due to an alteration of structure. The ordinary theory for the effect in a transverse field does not explain the results obtained. The effect is possibly due to a further structural change. J. J. S.

1616. *Properties of Electrolytic Iron Melted* in vacuo. **T. D. Yensen.** (University of Illinois, Bull. 11. No. 72. pp. 1–71, March 9, 1914.)—Describes experiments on the magnetic and mechanical properties of many different samples of iron, mostly electrolytic, containing various percentages of carbon from 0·0080 % to 0·181 %. To obtain the extremely low-carbon irons it was necessary to melt the iron *in vacuo* to avoid contamination, for, while it is found that a low-carbon iron melted *in vacuo* loses 50 to 90 % of its original carbon content, pure iron melted in an atmosphere of CO under atmospheric pressure absorbs both C and O, thus giving an iron of inferior magnetic quality. Electrolytic iron melted *in vacuo* is found to be superior to any existing grade of iron, the results obtained being summarised in the table on the opposite page.

The max. permeability is seen to reach 19,000 for a flux-density of 9500 gauss, while the hysteresis loss is less than half that of the best grades of commercial transformer iron, two samples of which were examined in the same way as the other specimens for the sake of comparison. The low electrical resistance is a defect which may be remedied by the addition of Si or Al. These elements increase the electrical resistance without materially affecting the magnetic quality of the iron, and experiments on such alloys

RODS THOROUGHLY ANNEALED AT 900° C.

Description of Iron.	Furnace used for Melting.	Carbon % (Analysis).	Max. Permeability.	Flux Density for Max. Permeability.	Hysteresis Loss (Ergs per $cm.^3$ per Cycle).		Coercive Force for $B_{max.} = 15,000$.	Retentivity for $B_{max.} = 15,000$.	Spec. Resist. at 20° C. (microhms-cm.)
					$B_{max.} = 10,000$.	$B_{max.} = 15,000$.			
Electrolytic	Vacuum	0·0104	19,000	9500	813	1640	0·29	12,100	10·00
"	"	0·0110	16,500	8500	880	1860	0·32	12,600	9·95
"	"	0·0090	16,000	6500	895	1600	0·30	10,600	10·20
"	"	0·0120	15,400	5000	902	1710	0·31	8100	9·90
"	"	0·0120	13,100	6200	980	1760	0·32	9100	10·03
"	"	0·0196	12,900	5500	1165	2180	0·40	10,200	9·85
"	"	0·0080	12,600	5500	955	1850	0·29	9300	9·70
"	"	0·0150	12,250	6000	953	1830	0·33	9000	10·16
"	"	0·0110	12,000	9000	1240	2500	0·36	10,100	9·70
"	"	0·0080	11,900	8000	1190	2120	0·35	9000	10·05
"	"	0·0099	11,600	5000	995	1940	0·30	9000	9·70
"	"	0·0095	11,250	4500	1155	2180	0·40	10,000	10·00
"	"	0·0090	11,050	5500	—	—	—	—	9·94
"	"	0·0080	10,500	9000	1470	2640	0·40	10,600	9·87
"	"	0·0450	8050	4500	1255	2000	0·40	9600	10·30
Average......................	....	0·0125	12,950	6550	1060	1990	0·34	9940	9·96
Average for iron melted in resistance furnace		0·1000	1965	3930	—	—	—	—	13·53
0·05 % C. added	Vacuum	0·0180	8600	6000	1405	2300	0·40	10,000	10·24
0·10 % C. "	"	0·0120	7600	7000	1710	3190	0·50	10,700	10·64
0·50 % C. "	"	0·1810	4400	5500	1910	—	—	—	12·40
Swedish charcoal iron remelted *in vacuo* ...		0·0080	10,350	7000	1290	2640	0·48	11,200	10·30
Commercial Grades.									
Swedish charcoal iron cut from plate		0·1630	4870	6600	2490	4530	0·95	8000	10·57
Standard transformer steel [1]		—	3850	7000	3320	5910	1·33	9900	11·09
4 % silicon steel [1]		—	3400	4300	2260	3080	0·88	5400	51·15

[1] Received manufacturer's standard anneal.

are now proceeding. A table giving the results of mechanical tests on the different specimens of iron employed, as well as a number of microphotographs are included, while in the Appendices are photographs and a detailed description of the apparatus together with an extensive bibliography of the subject. J. W. T. W.

1617. *Appearance of Galvanic Resistance in Supra-conductors when brought into a Magnetic Field.* **H. K. Onnes.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 987–992, April 28, 1914. Communication No. 139f. from the Phys. Lab., Leiden.)—In the author's last paper dealing with supra-conductors [Abstract No. 1121 (1914)] he had taken into consideration the possibility that resistance might be generated in such conductors by a magnetic field, and the behaviour of the magnet therein described seemed to show that the effect, if produced, would be very small. The field of the coil in that case amounted to several hundred gauss. In the experiments now described it was found that a coil with tin wire prepared in the author's manner showed a considerable resistance in a field of 10 kilogauss when cooled to 2° K., and this resistance decreased more slowly than proportionally when the field was reduced to 5 kilogauss. A lead coil which had shown the super-conducting effect was then placed in the cryostat in such a position that the plane of the windings coincided with the lines of force of the applied field. This coil remained super-conducting with ½ amp. passing through it. Then the magnetic field was applied (10 kilogauss), and there was at once a considerable resistance; the sudden change takes place at >500 and <700 gauss, both for 4·25° K. and for 2° K. The introduction of the magnetic field has apparently the same effect as heating the conductor. In the case of tin, the same behaviour is observed, but the sudden change takes place at a lower value of the field (*ca.* 200). This effect is being still further investigated. L. H. W.

1618. *Diamagnetic Properties of the Elements follow a Periodic Law.* **P, Pascal.** (Comptes Rendus, 158. pp. 1895–1897, June 22, 1914.)—Previous investigations, partly unpublished, have led to the determination for each element of a coefficient of atomic magnetisation, χ_A, which remains constant in compounds of simple structure, and is in many cases identical with that furnished by direct study of the element. The curve constructed with the atomic weights as abscissæ and the values of log χ^A as ordinates consists of a series of regular broken lines which are of similar aspect and are reproduced periodically. Elements with atomic weights less than 20 and also the magnetic elements are not in accord with this arrangement. On the broken lines, homologous points correspond exactly with the homologous elements of the same natural family, S, Se and Te being situated at minima, and Cl, Br and I at one set of maxima and P, As, Sb and Bi at another set. Further, the curves connecting homologous points are in all cases rectilinear. T. H. P.

1619. *On the Non-cyclic Change.* **L. Steiner.** (Terrestrial Magnetism, 19. pp. 78–80, June, 1914.)—The non-cyclic change as defined by Chree is the difference of the two consecutive midnight-values of the magnetic elements on a quiet day. Instead of taking the difference of the midnight-values the author has taken the difference of the daily means on two consecutive quiet days. He has chosen the observations at the magnetic observatories of the

U.S. Coast and Geodetic Survey, the uniformity in the selection of the quiet days for the different places being thus presumably best secured. The geographical positions of these places are :—

	Latitude (North).	Longitude (West of Greenwich).
Sitka...........................	57° 08′	135° 20′
Baldwin	38 47	95 10
Cheltenham	38 44	76 51
Honolulu...	21 19	158 04
Vieques, Porto Rico......	18 09	65 26 (old location)

In a table are given the mean values of the differences of the daily means on two consecutive quiet days. The striking thing is the general constancy of sign (and in general, too, its amount for the same station) of the difference in H (+) and in V (—) : the sign and amount of the difference in D is very changeable. In another table is given the distribution of the signs of the differences. There are further set out the differences of the daily means (for horizontal and vertical intensity) on each two consecutive quiet days for Pola, Potsdam, and O'gyalla for a few years. Some attempts with Tokyo, Manila, and Mauritius did not give as definite a result, but throughout there is a tendency for the plus sign of the difference in H, and the minus sign in that in V. From the two consecutive midnight-values on calm days for Zikawei 1904–1907 there is a similar strong tendency. Although the calculations embrace only a few years yet they show the general tendency towards regularity of the differences of daily means on two consecutive quiet days. If on two consecutive quiet days there is formed the difference for every hour there is obtained what may be considered as the "non-cyclic" change for the different hours. Forming the difference of every hour and diminishing these differences by the difference of the daily mean values on these two consecutive quiet days, we get the diurnal inequality of the non-cyclic change. This diurnal inequality shows how the difference of the daily means on the two consecutive quiet days originated.

Proceeding in this way the expectation of finding a regular daily inequality has not been entirely fulfilled. Although there was a tendency to regularity, a definite result did not ensue. But things changed when those pairs of consecutive quiet days whose differences were positive, were separated from those with negative differences. A regular inequality was found, which may be expressed as follows:—

From the morning hours (about 7h. to 9h. a.m.) to the afternoon hours (4h. to 6h. p.m.) the differences are of the same sign as the difference of the daily means; during the night hours they are of contrary sign. Or, in other words, if the difference of the daily means on two consecutive quiet days is + —, then the differences from morning (about 7h. to 9h. a.m.) till afternoon (about 4h. to 6h. p.m.) are > <, and during the night (about 6h. p.m. to 7h. a.m.) they are < > than the difference of the daily means.

This rule holds good for the declination as well as for the horizontal and vertical intensity. For Sitka the rule is not so conspicuous as for the other stations to which the investigations apply. As a sample the results are given for Baldwin in 1907 in a table in the original. In the second column is the mean value of the differences on two consecutive quiet days, in the third column the number of those pairs of days, from which the results have been derived. The daily inequality values given are smoothed-out values, obtained by the formula $(a + 2b + c)/4$.

The possibility remains that the inequality, stated above, may be only a consequence of the fact that, in general, the elements are changing more during the daytime than during the night. E. O. W.

1620. *The C. I. W. Combined Magnetometer and Earth Inductor.* **J. A. Fleming** and **J. A. Widmer.** (Terrestrial Magnetism, 18. pp. 105–110, Sept., 1913.)

1621. *Improvement of Appliances for Measurement of the Earth's Magnetic Elements.* **L. A. Bauer.** (Terrestrial Magnetism, 19. pp. 1–18, March, 1914. Progress Report of Department of Terrestrial Magnetism of the Carnegie Inst. of Washington.)—From the information given in the Report it appears to be theoretically possible to construct an apparatus for measuring, by electrical means, the intensity of the earth's magnetic field more expeditiously and, in general, with greater accuracy than with present magnetic methods, provided the necessary precautions be taken. Up to the present time, as far as is known, no such apparatus has as yet been put in final form, or at least no series of comparisons with the best type of modern magnetometer, sufficiently accurate and extensive, has been published. Considerable experimentation will yet be required before the question can be seriously considered whether it will be entirely advantageous, even for observatory purposes, let alone field work, to replace the present magnetic methods by electrical ones. It is believed that the greatest gain to science will ultimately result if the electrical devices be regarded as supplementing rather than supplanting the present magnetic instruments. L. H. W.

RADIOLOGY AND ELECTROPHYSIOLOGY.

1622. *Absolute Measure of Röntgen Rays and γ-Rays in Biology.* **B. Szilard.** (Archives d'Él. Médicale, 22. pp. 24–51, July 10, 1914.)—It is proposed that in future, measurements of Röntgen and γ-rays employed biologically shall be made by the ionisation method, and that the value of these forms of energy shall be expressed in the number of ions they are capable of creating. The biological unit chosen is that quantity of energy capable of producing 10^{12} ions in air under normal conditions. It is proposed to call this unit a mega-megaïon. The qualitative unit of the rays is to be their coefficient of absorption by air. An apparatus is described in detail, by which the absolute values can be read directly by means of an indicator which moves over a scale graduated in the above units. This apparatus acts independently and at a distance from the installation producing the Röntgen rays. It indicates directly and exactly, without any calculation, the value of energy at the surface. From this, by means of the deduced formulæ the absolute value of the energy on a unit surface or in a unit volume at any depth may be calculated by multiplication or division, or may be obtained by simply reading from the curves which are given. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1623. *Atomic Weights.* **F. H. Loring.** (Chem. News, 109. pp. 169–170, April 9, 1914.)—Probably the chemical elements can be broadly divided into two classes: (1) Whole-number atomic weight elements which have no associates differing from them in atomic weight; (2) whole-number atomic-weight elements composed of, or containing, chemically non-separable associates of different atomic weight. The author gives a list of elements with their experimental atomic weights built up out of whole numbers of "meta-elements" or "isotopes." Thus:

$$\text{Chlorine} = (40 \times 1 + 35 \times 10)/11 = 35{\cdot}4545.$$
$$\text{Iron} = (55 \times 1 + 56 \times 10)/11 = 55{\cdot}90\ ;$$

whereas cobalt = 59·00. In some cases the atomic weight thus arrived at is common to two or three elements. This would be fatal to the scheme but for parallel cases among the radio-elements, suggesting that though the atomic weights are the same, the electric or electronic systems may differ.

E. E. F.

1624. *Active Nitrogen.* **H. B. Baker, E. Tiede, R. J. Strutt, and E. Domcke.** (Nature, 93. p. 478, July 9, 1914.)—The experiments of Tiede and Domcke and of Strutt and Baker were repeated each in the presence of the other pair of investigators. As a result it appears that a sample of nitrogen may be made to give the glow more easily if it is mixed with a trace of oxygen. On the other hand, the purest nitrogen with which all the authors have worked in the joint experiments in London is capable of giving a brilliant glow under the experimental conditions used by Baker and Strutt. [See Abstract No. 979 (1914).]

L. H. W.

1625. *Thermoelectric Method for the Determination of the Purity of Platinum Ware.* **G. K. Burgess** and **P. D. Sale.** (Washington Acad. Sci., Journ. 4. pp. 282–287, June 4, 1914. Paper read before the Amer. Chem. Soc., April 6, 1914.)—The classification of platinum ware as to purity in terms of its evaporation at a definite temperature, say 1200°, appears to give doubtful results, and necessitates a tedious and delicate operation, while the application of the temperature coefficient of electrical resistance, which is diminished by any admixture, yields the most exact indications, but is convenient only with wire. The following thermoelectric method is accurate and rapid and does not deface the objects tested. To the rim of the crucible, for instance, are soldered two pure Pt-wires, 0·1—0·2 mm. in diam., which are connected with an ordinary pyrometer galvanometer or millivoltmeter. One junction is heated by a small oxygen-gas or other blast flame, whilst the other is kept cool by an air blast, radiation being prevented by the interposition of an asbestos sheet suitably shaped. Temperatures are measured by means of a thermocouple of Pt and Pt containing 10% of Rh. If it is thought advisable, the pure Pt-wires may be placed simply in contact with the crucible and not soldered; they are suitably made of Heraeus normal thermo-element wire drawn down. A number of specimens of platinum have been examined by this method, the e.m.f. of pure Pt against the crucible being calculated as iridium-content. In a few instances, the stated and found iridium-contents agree exactly, but these often diverge widely, and in only one case was less Ir found than stated. The method is accurate to 0·01 %, but it does not distinguish the various impurities. Where stiffness is required in platinum crucibles, it would probably be preferable to add Rh instead of Ir, owing to its lesser volatility. T. H. P.

1626. *Freezing-point Diagram of Lead-Arsenic Alloys and Melting-point o, Arsenic.* **W. Heike.** (Int. Zeitschr. Metallog. 6. pp. 49–57, April, 1914.)—The author has heated lead and arsenic together in an evacuated porcelain tube heated in a furnace capable of continual rotation, the fused mass being thus kept well mixed. In contradiction of the results of earlier work, it is found that the two constituents are completely miscible in the liquid state, whilst crystalline As is completely insoluble in crystalline Pb and the latter soluble in the former only to a minimal extent. The freezing-point diagram consits of two branches meeting in a eutectic point at 288°, the corresponding proportion of As present being 8·25 atom. per cent. Although the highest proportion of As that could be obtained in the alloys was 82·8 atom. per cent., extrapolation of the eutectic time curve indicates that no chemical compounds are formed and that the melting-point of As is 852°. T. H. P.

1627. *Cracking of Drawn Brass.* **E. Jonson.** (Eng. Record, 69. pp. 415–416, April 11, 1914. Mech. Eng. 34. pp. 153–154, Aug. 14, 1914.)—Cracking is more likely to occur in a hard than in a soft alloy, especially when hardened with tin and iron. Season cracking occurs only in copper alloys that have been cold-worked. Ten per cent. aluminium-bronze hot-rolled bars did not suffer from season cracking whilst cold-drawn bars of the same material did crack. In the new Catskill (New York) aqueduct hundreds of studs have been found cracked, the cracks occurring in the unthreaded portion, and only a few studs had cracks in the thread, which indicates that machining off the surface as is done in cutting threads eliminates the danger of cracking.

It is supposed that season cracking is a bursting due to initial stress augmented by temperature stress. Some results are given of the differences in length of a cold-drawn manganese-bronze rod resulting from cutting down the diameter, and the total stress in each layer is calculated.

Specifications for rolled, extended and drawn brass are proposed. C. O. B.

1628. *Study of the Annealing Process for Malleable Castings.* **O. W. Storey.** (Metallurgical and Chem. Engin. 12. pp. 388–389, June, 1914.)—Contains the results of experimental work carried out by E. L. Leasman under the author's direction to determine the effect of packing materials, temperature of annealing, time of annealing, and rate of cooling on the annealing process. A large number of packing materials were used including lime, sand, alundum, rolling-mill scale, resistor carbon, manganese dioxide, cement, fine and coarse fireclay, iron oxide, alumina, fine graphite, and carborundum. The results obtained with these materials showed that (1) the nature of the packing material does not influence the interior of "black heart" malleable cast iron; (2) the ordinary packing materials do not directly affect the skin structure of malleable cast iron; (3) a loose packing material, allowing a free circulation of oxidising gases will result in a carbonless rim; (4) a slightly oxidising atmosphere will result in a steely rim; (5) a neutral atmosphere will result in a rim having the same structure as the interior of the iron.

With regard to the temperature required, it was found that with an annealing time of 50 hours, a temperature of 860° was required to secure a complete breakdown of the cementite; no decomposition could be observed in specimens annealed below 670°; annealing at 740–760° for 50 hours resulted in a partial breakdown.

The results of the experiments made to determine the correct time of annealing at various temperatures showed that a malleable structure was obtained in 86 hours at 870°. By raising the temperature to 985° the time necessary was only 18 hours, whereas at 740° the necessary time was 70 hours. The lower temperatures give better results and cost less in upkeep of furnaces. The rate of cooling was found to have considerable influence on the product: a fast rate results in a steely structure, whilst a very slow rate results in a ferrite rim. The critical range of cooling is between 740° and 830° and if the rate of cooling in this range is sufficiently slow, all the carbon in the undecomposed austenite will be precipitated in this range and the rate of cooling below 700° has little effect. The mechanism of the breakdown of the iron carbide has been studied and the present results seem to show that cementite does not break down directly, but decomposes from the solid solution or austenitic condition. C. O. B.

1629. *Three-metal Bronzes.* **A. M. Blow.** (Metallurgical and Chem. Engin. 12. pp. 461–466, July, 1914.)—A study is made of the effect of adding lead, zinc, phosphorus, manganese, aluminium and iron to bronze. Equilibrium diagrams of the various systems are given and the changes taking place during solidification and cooling are used to explain the effects produced. Bronzes containing appreciable quantities of lead are known as plastic bronzes.

The effect of lead on the physical properties and microstructure of bronze is simple and a fourth metal is often added to make the desirable properties more pronounced. Under normal conditions, the only difference between a high- and a low-lead bronze is the amount of lead distributed throughout the mass after solidification. Microscopically, plastic bronze shows black patches of lead set in a ground mass of bronze and in this respect it differs from most anti-friction alloys. In making plastic bronze it was found that nickel, sulphur, or phosphorus prevents the segregation of copper and lead. Other than for bearing metals, lead affects bronze by giving it superior machining properties, also giving it a patina much appreciated in bronze statuary.

With regard to the action of zinc on bronze, small quantities such as 2% cause little effect on the structure, and the physical properties are only slightly altered. With more zinc quite different alloys are produced, and with 40 per cent. zinc and a little tin, Muntz metal structure is obtained. One of the principal effects of zinc on bronze is the greater ease of cold-rolling and forging. The addition of phosphorus to bronze greatly increases its hardness or resistance to wear, but the tensile strength, elastic limit, and elongation are impaired in proportion to the phosphorus added. C. O. B.

1630. *Change of Phase under Pressure. I. The Phase Diagram of Eleven Substances with Especial Reference to the Melting Curve.* **P. W. Bridgman.** (Phys. Rev. 3. Ser. 2. pp. 126–141, Feb., and pp. 153–208, March, 1914.)—The data presented cover a pressure-range up to 12,000–13,000 kg./cm.² and a temperature range from 0° to 200°. Over this entire range the relation between melting-temperature and pressure has been measured, and the difference of volume between solid and liquid has been determined. Eleven substances were experimented with, including simple and complicated organic compounds, and three elements—namely, potassium, sodium, carbon dioxide, chloroform, aniline, nitrobenzene, diphenylamine, benzene, carbon tetrachloride, *o*-cresol, and phosphorus. The effect of pressure on the melting-point may be illustrated by the following examples—

Pressure =	1	6000	12,000 kg./cm.².
Potassium	62·5°	185·4°	179·6° C.
Sodium	97·6°	142·5°	177·2°
Carbon dioxide	—56·6°	83·1°	98·5°
Chloroform	—61·0°	82·4°	107·9°
Aniline	—6·4°	93·2°	165·3°
Nitrobenzene	5·6°	122·3°	198·6°
Diphenylamine	54·0°	180·9°	—
Benzene	5·4°	181·2°	—
Carbon tetrachloride	—22·6°	149·5°	—
o-Cresol	30·8°	102·9°	—
Phosphorus	44·2°	191·9°	—

Four of the substances were found to exist in new solid forms under high pressures, namely, CCl_4 (two new forms), *o*-cresol, benzene, and phosphorus (two forms). One of the new forms of phosphorus transforms itself reversibly into yellow phosphorus under proper conditions, while the other is stable under atmospheric conditions. It is obtained from yellow phosphorus irreversibly at 200° and 12,000 kg., but could not be obtained in the same way from red phosphorus. The new form of phosphorus is greyish-black like graphite, breaks with a similar greasy-looking fracture, and will mark on paper. It is stable in the air although slightly deliquescent, is ignited with difficulty by a match, and cannot be exploded with a blow from a hammer as red phosphorus can. It is a conductor of electricity and a rectifier. It has a very high density, 2·69 against 2·34 for red and 1·9 for yellow phosphorus. If sealed into a heavy glass capillary and heated it sublimes and condenses to yellow and red phosphorus in the colder parts of the tube exactly as red phosphorus powder does under the same circumstances. The chief object of the research was to determine the form of the melting-point curve with change of pressure and in particular to test two rival theories as to the ultimate fate of the curve, viz. whether a critical point is reached at which liquid and solid become identical or whether (as Tammann supposes) the curve reaches a maximum melting-point and then falls again. All the data now recorded agree in showing that there is no evidence for either a critical point or a max. melting-point. The results suggest strongly, so far as such a conclusion can be suggested by results over a limited range, that the melting curve continues to rise indefinitely to higher pressures and temperatures. In any case, the pressures now reached exceed considerably those that have been predicted for the supposed critical point and the supposed maximum, which can therefore only exist, if at all, in the most extreme ranges of pressure.

T. M. L.

1631. *Influence of Colloids and Fine Suspensions on Solubility of Gases in Water.* IV. *Solubility of Nitrous Oxide at Pressures lower than Atmospheric.* **A. Findlay** and **O. R. Howell.** (Chem. Soc. Journ. 105. pp. 291–298, Feb., 1914.)—Measurements are given of the solubility of nitrous oxide at low pressures from 250 to 1000 mm., overlapping with and extending the observations already made under pressures from 750 to 1400 mm. [Abstract No. 1167 (1910)]. In every case a minimum of solubility was observed at some intermediate pressure, although in the case of water containing silicic acid the minimum is very shallow. Nitrous oxide gave a well-marked minimum in starch solutions, although none appeared when CO_2 was used: the exceptional behaviour of CO_2 with starch calls for further investigation. [See Abstract No. 1870 (1913).] T. M. L.

1632. *Colours of Cobalt Salts in Solution.* **J. E. Marsh.** (Chem. News, 109. p. 171, April 9, and p. 193, April 24, 1914.)—A solution of sodium chloride and cobalt chloride in a mixture of water and acetone, which is pink when cold, separates on warming into two solutions, the upper one being light blue in colour and the lower dark blue. The upper layer is expelled gradually, and the lower layer changes its colour gradually as the temperature is raised. The solutions will mix again on cooling to the original homogeneous pink solution. When cooled without mixing the upper layer becomes almost colourless, but becomes blue again on warming, while the lower layer changes from blue to pink. The concentration of the solution may be varied within certain limits. A good effect is given by taking the salts in the proportion of $2NaCl$ to $CoCl_2$, and about equal volumes of acetone and water. Cobalt chloride alone without the sodium chloride will bring about the separation in much the same way, but a higher temperature is required.

Potassium and cobalt bromides in acetone and water give much the same effect. With lithium and cobalt chlorides the solution when cold is blue. On warming, the light and dark blue layers are obtained, and on cooling without mixing the upper layer retains its colour, while the lower layer changes from blue to pink. T. M. L.

1633. *Note on Osmotic Pressure.* **W. R. Bousfield.** (Roy. Soc., Proc. Ser. A. 90. pp. 41–45, April 1, 1914.)—The conception that the vapour in the molecular interspaces of a solution behaves on compression of the solution approximately as a perfect gas leads to the same general result as that which is derived from thermodynamical considerations. L. H. W.

1634. *Osmotic Compressibility of Emulsions considered as Fluids with Visible Molecules.* **J. Perrin.** (Comptes Rendus, 158. pp. 1168–1171, April 27, 1914. **R. Constantin.** (Comptes Rendus, 158. pp. 1171–1173, April 27, 1914.)—If van der Waals' equation be considered to hold good for the osmotic pressure of emulsions, it is possible to deduce a relationship between the number of particles in unit volume of a homogeneous emulsion and the constants of the van der Waals equation. The equation also involves the Avogadro-number, which gives the actual number of molecules in a gm. molecule of any substance. The correctness of the equation was tested by counting the number of granules at different heights and plotting out two functions of these as a straight line (in agreement with theory), of which one intercept gave the Avogadro-number. Using spherical granules of gutta-percha of radius $0{\cdot}33\,\mu$ the granules were photographed with a horizontal microscope, the focus of which included a thickness of 3 to $5\,\mu$. The granules in a series of horizontal strips of $2{\cdot}77\,\mu$ in height were counted on three negatives to the number of 26,000. Twenty-six concentrations were thus measured, ranging from 0·0028 to 0·0760; large and increasing deviations from the simple van't Hoff law were observed at concentrations over 0·0075, but the van der Waals equation gave concordant figures at least up 0·0800.

The chief results obtained were as follows :—(1) The Avogadro-number was found to be 60×10^{22} as compared with the value 65×10^{22} obtained by other methods. The constant *a* has a *negative* value, i.e. *the granules repel one another*. This repulsion can be explained as electrical in origin, provided that the thickness of the electrical double-layer on the surface is not negligible, and might have been foreseen from the theory put forward by Gouy in 1910. T. M. L.

1635. *Classification of Foaming Solutions*. **S. A. Shorter.** (Phil. Mag. 27. pp. 718–720, April, 1914.)—The author classifies such solutions under three heads: (1) Surface concentration thermodynamically reversible; special superficial viscosity or rigidity absent. (2) Surface concentration thermodynamically irreversible; special superficial viscosity or rigidity absent. (3) Surface concentration thermodynamically irreversible; the surface layers specially viscous or rigid. L. H. W.

1636. *Chemical Constants of Hydrogen*. **v. Kohner** and **P. Winternitz.** (Phys. Zeitschr. 15. pp. 393–397, April 15, 1914.)—The calculation of the integration constant or "chemical constant" of Nernst's vapour-pressure formula requires a suitable heterogeneous reaction in which the gas considered is the only one taking part. For hydrogen such a reaction is furnished by the reduction of mercuric oxide by hydrogen, which was studied by Brönsted [see Abstract No. 1188 (1909)]. Brönsted's data lead to the value $-1{\cdot}308 \pm 0{\cdot}15$ for the chemical constant, kinetic considerations indicating the number, $-1{\cdot}17$. T. H. P.

1637. *Nernst's Approximation Formula*. **P. Winternitz.** (Phys. Zeitschr. 15. pp. 397–399, April 15, 1914.)—If Q represents the molecular heat of evaporation or dissociation and T the temperature at which the vapour or dissociation pressure equals atmospheric pressure, the ratio Q : T should, according to the laws of Trouton and of le Chatelier and Forcrand, be constant. On the other hand, Nernst's approximation formula for vapour pressure indicates that the above ratio cannot remain constant at either very high or very low temperatures. It is found experimentally that for hydrogen and for tungsten the values of Q : T are 15·0 and 41·0 respectively. Since the corresponding values derived by means of Nernst's formula are 17·0 and 42·2, the conclusion drawn from this formula is in good agreement with the experimental results. T. H. P.

1638. *Theory of the Dissociation of Gases*. **O. Stern.** (Ann. d. Physik, 44. No. 4. pp. 497–524, June 4, 1914.)—A mathematical paper which cannot be usefully abstracted. L. H. W.

1639. *The Theory of Electrolytic Dissociation*. **S. Arrhenius.** (Chem. Soc., Journ. 105. pp. 1414–1426, June, 1914. Faraday Lecture.)

1640. *Mercurous Sulphate for Standard Cells*. (Ann. d. Physik, 44. No. 5. p. 816, June 19, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—At the suggestion of the Reichsanstalt, Messrs. E. de Haën have undertaken to prepare mercurous sulphate on a commercial scale, following the instructions given them. The mercurous sulphate is kept under a saturated solution of cadmium sulphate, so that it may be used at once for Weston normal cells. The firm adopts the precipitation method and obtains a permanent preparation. The entire quantity prepared is submitted to the Reichsanstalt, where its behaviour is tested by making up standard cells with it which are kept under observation for from 2 to 3 months. F. E. S.

1641. *Chemical Action that is Stimulated by Alternating Currents.* **S. G. Brown.** (Roy. Soc., Proc. Ser. A. 90. pp. 26–32, April 1, 1914.)—Some experiments are described with the object of showing that the polarisation of a simple voltaic cell (Zn and C in dilute sulphuric acid) is completely removed by passing an alternating current of suitable strength through the cell. Certain applications are discussed, but it was found that in no case was a relay effect obtainable, the d.c. output being always smaller than the a.c. input. Platinum and also gold wires are oxidised under the combined action of the two currents. L. H. W.

1642. *Electrolytic Rectifiers.* **G. Schulze** and **R. Lindemann.** (Phys. Zeitschr. 15. pp. 254–260, March 1, 1914.)—The authors criticise Zenneck's conclusion [Abstract No. 172 (1913)] that the rectifying action is due to diffusion, and that this explains the failure of the cells to rectify very rapidly alternating currents. They incline to a theory involving electronic processes in an excessively thin gaseous layer formed on the surface of the valve metal. They show, theoretically and experimentally, that Zenneck's results are explained on this view if due account is taken of electrostatic capacity and of the minimum p.d. required for transmission of currents in the unopposed direction. Some rectifying action ought to remain even at the frequencies of wireless telegraphy. E. E. F.

1643. *Polarisation in the Aluminium Rectifier.* **C. W. Greene.** (Phys. Rev. 3. Ser. 2. pp. 264–272, April, 1914.)—The author, with the aid of a rotating contact-maker, has measured by a potentiometric method the counter-e.m.f. of an Al rectifying cell at various extremely short intervals of time after charging has taken place. The kathode used was Pt; ammonium aluminium sulphate and potassium dichromate were employed as electrolytes, although no reason is given why these were chosen. The max. applied voltage in no case exceeded 19 volts, and only direct current was applied, so that only the effect of diffusion (decay with time) is studied [not the complex rectifying process such as occurs with alternating current]. The author summarises his conclusions as follows:—(1) The condenser method of measuring the counter-e.m.f. introduces an error due to the taking of a charge from the rectifier. (2) The rectifier does not behave as an ordinary condenser. (3) When Al is used as the anode, the counter-e.m.f. alone accounts for the reduction of the current to its exceedingly small value. (4) The results obtained in this investigation are apparently in accord with the gas film theory and the theory of ionic diffusion. L. H. W.

1644. *Electrochemical Properties of RaB and ThB.* **Z. Klemensiewicz.** (Comptes Rendus, 158. pp. 1889–1891, June 22, 1914.)—The author has made experiments on the question of the similarity of RaB, ThB, and lead. The method employed consisted in the determination of the ratio of partition of the radio-active substance between the amalgam of lead and a solution of lead nitrate. From the results it is concluded that the normal electrochemical potentials of RaB and ThB differ from each other and from lead by less than 2×10^{-5} volt. E. M.

1645. *Electrolytic Deposition of Metal in (Electrolytic) Valve Cells.* **G. Schulze.** (Ann. d. Physik, 44. 7. pp. 1106–1120, July 17, 1914. Communication from the Physikal-Techn. Reichsanstalt.)—When a tantalum electrode immersed in a solution of copper sulphate is submitted to the action of an alternating current, it undergoes "formation." After the formation, only a definite fraction (about 85 %) of the total copper is deposited in the electrodically active form when the "flow current" passes (Ta kathode); the remainder deposits as a fine powder in the electrolyte. The Ta remains blank. The electrodically active copper is again dissolved when the "throttled current" begins to pass, the cell remaining open; as soon as the copper has dissolved the cell becomes closed.

The amount of copper which is deposited in the active form is almost independent of (*a*) the "formation" tension or the thickness of the active layer of the Ta, (*b*) the current density, when high current densities are used, (*c*) the concentration of the electrolyte. It increases with the temperature, with diminishing current density for low current densities, and with decreasing strength of the acid from which the salt used is derived. The addition of other electrolytes to the solution of copper sulphate diminishes the total amount of copper deposited all the more, the lower its minimal tension is. For example, if a 0·4 mol. $CuSO_4$ solution is made 0·08 mol. with respect to sodium sulphate, not copper, but sodium is deposited, which then liberates hydrogen from the water.

When the kathions of the heavy metals are arranged in a series depending on the fraction of the metal which is deposited in the electrodically active form, the order is the same for the nitrates, sulphates, and acetates of these metals. Since Ta is "formed" by the alternating current in solutions of the salts of heavy metals, it is probable that the observed phenomena are connected with the existence on the tantalum of a layer of oxide of molecular thickness.

Aluminium exhibits the same behaviour as Ta, but in an incomplete manner, since in the electrolytes used the valve action does not exist or is incomplete. [Compare Abstract No. 1565 (1913).] T. S. P.

1646. *Passivity of Metals.* **G. Senter, G. Grube, G. Reichinstein, H. S. Allen, M. Le Blanc, G. C. Schmidt, G. Schulze, A. P. Schoch.** (Faraday Soc., Trans. 9. pp. 203–290, March, 1914.)—This discussion includes papers on various aspects of the theory of passivity, contributed by the authors enumerated above. L. H. W.